INSTRUCTION MANUAL

TYPE RM 545B OSCILLOSCOPE

MANUFACTURERS OF CATHODE-RAY OSCILLOSCOPES

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INSTRUCTION MANUAL

Serial Number _____

TYPE RM545B OSCILLOSCOPE

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869

WARRANTY

All Tektronix instruments are warranted against defective materials and workmanship for one year. Tektronix transformers, manufactured in our own plant, are warranted for the life of the instrument.

Any questions with respect to the warranty mentioned above should be taken up with your Tektronix Field Engineer.

Tektronix repair and replacement-part service is geared directly to the field, therefore all requests for repairs and replacement parts should be directed to the Tektronix Field Office or Representative in your area. This procedure will assure you the fastest possible service. Please include the instrument Type and Serial Number with all requests for parts or service.

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Abbreviations and symbols used in this manual are based on or taken directly from IEEE Standard 260 "Standard Symbols for Units" MIL-STD-12B and other standards of the electronics industry. Change information, if any, is located at the rear of this manual.

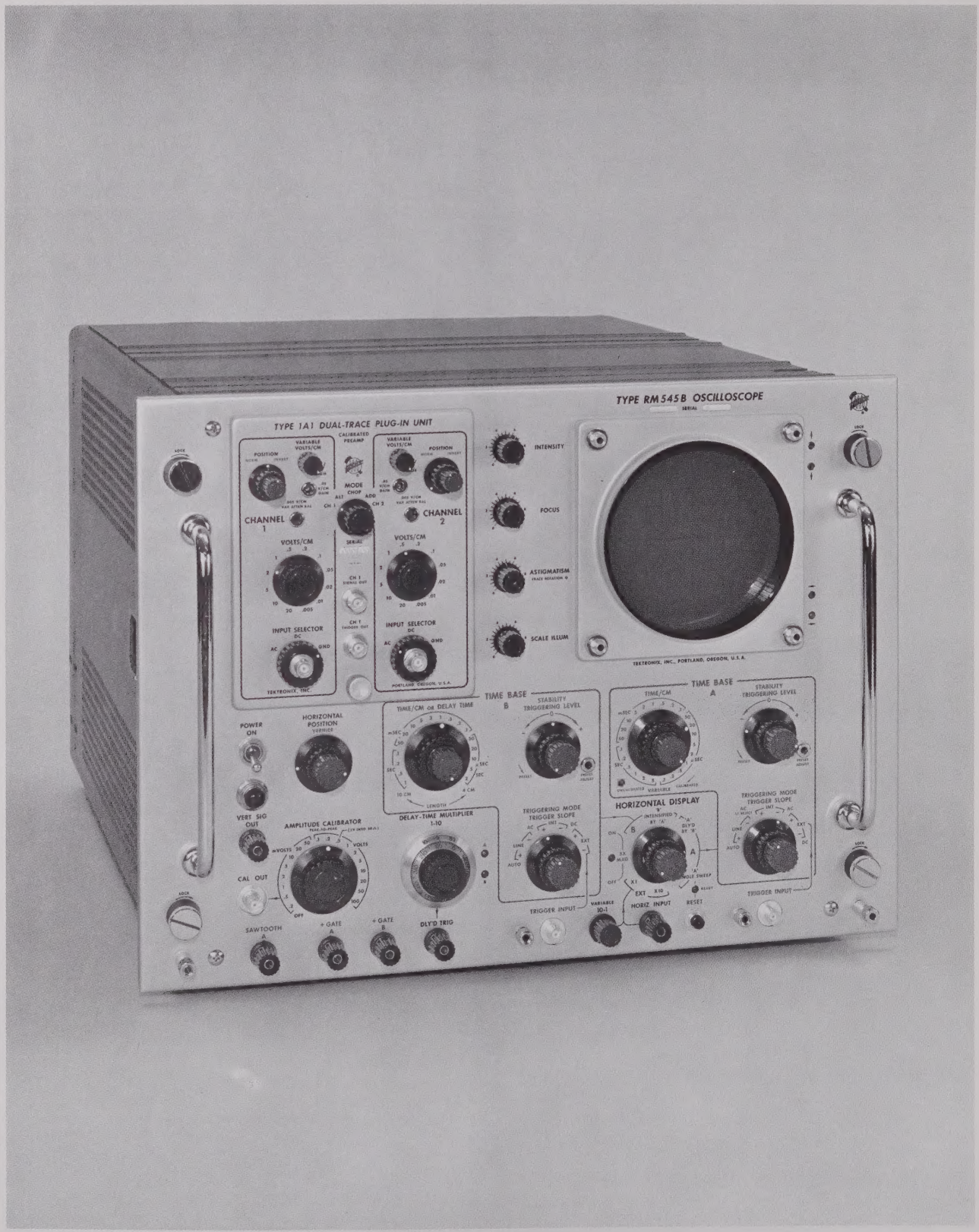


Fig. 1-1. Type RM545B Oscilloscope.

SECTION 1
TYPE RM545B SPECIFICATION

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

The Type RM545B Oscilloscope is a laboratory instrument designed to operate with all Tektronix letter-series or 1-series plug-in units. It features two separate time-base generators which may be used to provide delayed sweep operation. This feature permits very accurate time measurements and detailed observation of a waveform.

The instrument is ventilated with filtered forced air. To insure proper airflow through it, operation with the side panels removed is not recommended except as necessary for required maintenance or calibration. A minimum clearance of two inches around the instrument should be maintained. The Type RM545B will perform to requirements over an ambient temperature range from 0° C to +50°C after a warmup time of twenty minutes.

There are three catagories of characteristics for the Type RM545B; Electrical, Environmental, Mechanical. In the following table the characteristic and the performance to expect is stated, followed by information relating to the characteristic and performance.

ELECTRICAL

VERTICAL DEFLECTION SYSTEM

Characteristic	Performance Requirements
Frequency Response	DC to at least 30 MHz with plug-in having 7 ns or less risetime.
Risetime	10 ns or less with plug-in having 7 ns or less risetime.
Transient Response	Not more than ±1.25% (2.5% peak-to-peak) overshoot, rolloff, tilt or ringing associated with a fast-rise square wave.
Positioning Effect on Transient Response	Not more than 1.25% change in transient response when display is moved within center 5 cm of graticule.
Low Frequency Linearity	Not more than 1.5 mm compression or expansion of 2 cm signal over vertical width of graticule.
Deflection Factor	0.1 V (±3%) per cm of display.
DC Balance	Within ±2 cm of graticule center.
DC (thermal) Shift	Less than 1.25% tilt of flat top of applied square wave.
Trace Drift with Line Voltage Change	Not more than 1 cm. (line voltage ranges specified under INSTRUMENT POWER.)
Gain Change with Line Voltage Change	Not more than 1%. (Line voltage ranges specified under INSTRUMENT POWER.)

TRIGGERING

Time Base A	
[1]Trigger Sensitivity, INT	
AC	2 mm deflection, 150 Hz to 10 MHz; 1 cm deflection at 30 MHz.
AC LF REJECT	2 mm deflection, 30 kHz to 10 MHz; 1 cm deflection at 30 MHz.
DC	6 mm deflection, DC to 10 MHz.
AUTO	5 mm deflection at 150 Hz.

[1]**Minimum signal size or amplitude requirement for stable display.**

[1] Trigger Sensitivity, EXT	
AC	0.2 V, 150 Hz to 10 MHz; 1 V at 30 MHz.
AC LF REJECT	0.2 V, 30 kHz to 10 MHz; 1 V at 30 MHz.
DC	0.2 V, DC to 10 MHz; 1 V at 30 MHz.
AUTO	0.5 V at 150 Hz.
AUTO Repetition Rate	40 Hz ±10% with no triggering signal applied.
SINGLE SWEEP Triggering Sensitivity	0.5 cm
Maximum TRIGGER INPUT Voltage	50 V (DC + peak AC)

Time Base B	
[1] Trigger Sensitivity, INT	
AC	2 mm deflection, 300 Hz to 5 MHz; 1 cm at 10 MHz.
DC	6 mm deflection, DC to 5 MHz.
AUTO	5 mm deflection at 300 Hz.
[1] Trigger Sensitivity, EXT	
AC	0.2 V, 300 Hz to 5 MHz; 1 V at 10 MHz.
DC	0.2 V, DC to 5 MHz; 1 V at 10 MHz.
AUTO	0.5 V at 300 Hz.
Maximum TRIGGER INPUT Voltage	50 V (DC + peak AC)

HORIZONTAL DEFLECTION SYSTEM

Time Base A	
Range, Calibrated	0.1 μs/cm to 1 s/cm in 1-2-5 sequence.
Accuracy	Within ±3% of indicated rate with VARIABLE at CALIBRATED.
VARIABLE TIME/CM Range	Decreases sweep rate to as slow as 40% of value selected by TIME/CM switch.
Sweep Length	10.5 ±0.3 cm at 1 ms/cm.

Time Base B	
Range, Calibrated	2 μs/cm to 1 s/cm in 1-2-5 sequence.
Accuracy	Within ±3% of indicated rate.
Sweep Length Range	Continuous from greater than 10 cm to less than 4 cm.

SWEEP MAGNIFIER

Magnification Factor	X5
Magnified Sweep Accuracy	±5%
Sweep Mag Registration	Not more than ±5 mm horizontal trace shift at graticule center when switching 5X magnifier on or off.

VARIABLE TIME DELAY

Calibrated Delay Range	Continuously variable from less than 2 μs to at least 10 s.
Delay Time Accuracy	Within ±1%
Multiplier Accuracy	±0.2% of full scale (2 minor dial divisions)
Delay Time Jitter	Not more than 1 part in 20,000 of 10 times the B TIME/CM setting.

EXTERNAL HORIZONTAL AMPLIFIER

Deflection Factor (VARIABLE 10:1 fully clockwise)	
X1	Not more than 0.2 V/cm with 1 kHz signal applied.
X10	Not more than 2.0 V/cm with 1 kHz signal applied.
Variable Range	10:1 or more.
10:1 Attenuator Accuracy	Within ±3%.
X10 Attenuator Compensation	Not more than 5% aberration or tilt referenced to X1.

[1] **Minimum signal size or amplitude requirement for stable display.**

X1 DC Balance	Not more than 2 cm of horizontal shift when VARIABLE 10-1 is rotated.
Frequency Response (VARIABLE 10:1 fully clockwise)	DC to 350 kHz or more at 3 dB down.
Maximum HORIZ INPUT voltage	50 V (DC + peak AC)

AMPLITUDE CALIBRATOR

Voltage Output (Square Wave)	0.2 mV to 100 V in 1-2-5 sequence.
Accuracy	Within ±3% of selected value.
Symmetry	45% to 55% duty factor.
Repetition Rate	1 kHz ±25%.
Special Output	.5 V position provides 0.1 V ±3% into 50 Ω.

FRONT-PANEL OUTPUT SIGNALS

DLY'D TRIG	At least 5-V positive-going pulse occurring at the end of the delay period.
+ GATE B and + GATE A	At least 20-V square wave rising from 0-V base line. Time coincident with respective sweep. Recommended load at least 5 kΩ.
SAWTOOTH A	Ramp rises from 0 (±5 V) to at least +130 V; duration equal to A sweep time. (10 kΩ or larger load recommended).
VERT SIG OUT	1.2 V or greater no-load output per cm of display; source impedance approximately 1.5 kΩ in series with .022 μF.

CATHODE-RAY TUBE

Geometry	
Vertical	Not more than 1.5 mm bowing or tilt.
Horizontal	Not more than 2 mm bowing or tilt.
Focus	
Vertical	20 horizontal lines/cm distinguishable over center 4 cm of graticule; 15 horizontal lines/cm distinguishable in top and bottom cm.
Horizontal	20 time marks/cm distinguishable over middle 8 cm of graticule; 15 time marks/cm distinguishable in first and last cm.
Trace Rotation Range	Sufficient to align trace with center horizontal graticule line.
External Z-Axis Modulation	Intensity modulates at 15 V or less.

INSTRUMENT POWER

Line Frequency		50 to 60 Hz, single phase. (Can be modified for 400 Hz.)
Line Voltage Range		
SN 8880 and above		
115 V	Low	90 V to 110 V
	Medium	104 V to 126 V
	High	112 V to 136 V
230 V	Low	180 V to 220 V
	Medium	208 to 252 V
	High	224 V to 272 V
Below SN 8880		Within 10% of the following AC voltage for which it is wired: 108, 115, 122, 216, 230, 244.
Time delay		At least 15 seconds.

ENVIRONMENTAL

The following environmental test limits apply when tested in accordance with the recommended test procedure. This instrument will meet the preceding electrical performance requirements after environmental tests have been performed. Details on environmental tests may be obtained from Tektronix, Inc. Contact the local Tektronix Field Office or representative.

Temperature	
Operating	0°C to +50°C.
Non-operating	−40°C to +65°C
Altitude	
Operating	15,000 feet maximum
Non-operating	50,000 feet maximum
Transportation	Qualified under National Safe Transit Committee test procedure 1A.

MECHANICAL

Characteristic	Information
Construction	
Chassis	Aluminum alloy
Front-Panel	Aluminum alloy with anodized finish.
Cabinet	Blue vinyl painted.
Dimensions (overall, nearest 1/8th of inch)	
Height	14 in (35.6 cm)
Width	19 in (48.2 cm)
Depth	22 3/4 in (57.7 cm)
Connectors	A TRIGGER INPUT, B TRIGGER INPUT, and CAL OUT connectors are BNC type. All other front-panel connectors are binding post type.

SECTION 2
OPERATING INSTRUCTIONS

Change information, if any, affecting this section will be found at the rear of the manual.

General

To effectively use the Type RM545B, the operation and capabilities of the instrument must be known. This section describes the operation of controls and connectors, gives first time operating information and describes some basic applications for this instrument.

COOLING

A fan maintains safe operating temperature in the Type RM545B by circulating filtered air over the power supply rectifiers, regulators, and other circuit components. When in operation, the instrument must be placed so that the air intake at the back and the vents in the side panels are clear of any obstruction that might impede the flow of air. Allow at least 3 inches clearance at the rear of the instrument and 2 inches at each side. The side panels should be in place (except during maintenance adjustments) for proper air circulation inside the instrument. For further information about cooling requirements, refer to the Rackmounting instructions in the back of this manual.

The Type RM545B should never be operated without the fan running, since temperatures within the instrument will rise to a dangerous level in a few minutes. In this event, the thermal cutout switch disconnects the power and keeps it disconnected until the temperature drops to a safe level.

POWER REQUIREMENTS

General. Two possible methods of connecting the oscilloscope for use with the appropriate power supplies exist, and the method to be used is determined by the serial number of the instrument, as follows:

SN 8880 and Above

The Type RM545B can be operated from either a 115-volt or a 230-volt nominal line-voltage source. The Line Voltage Selector assembly on the rear panel converts the instrument from one operating range to the other. In addition, this assembly changes taps on the primary winding of the power transformer to allow selection of one of three regulating ranges. The assembly also includes the two line fuses. When the instrument is converted from 115-volt to 230-volt nominal operation, or vice versa, the assembly installs the proper fuse to provide instrument protection.

To convert from one nominal line voltage to the other and/or change regulating ranges, use the following procedure. (See Fig. 2-1).

1. Disconnect the instrument from the power source.

2. Loosen the two captive screws that hold the cover in the voltage selector switch base; then remove the cover by pulling it straight away from the base.

3. To change nominal line voltage selection, pull out the Voltage Selector plug (see Fig. 2-1), rotate it 180° and plug it back in.

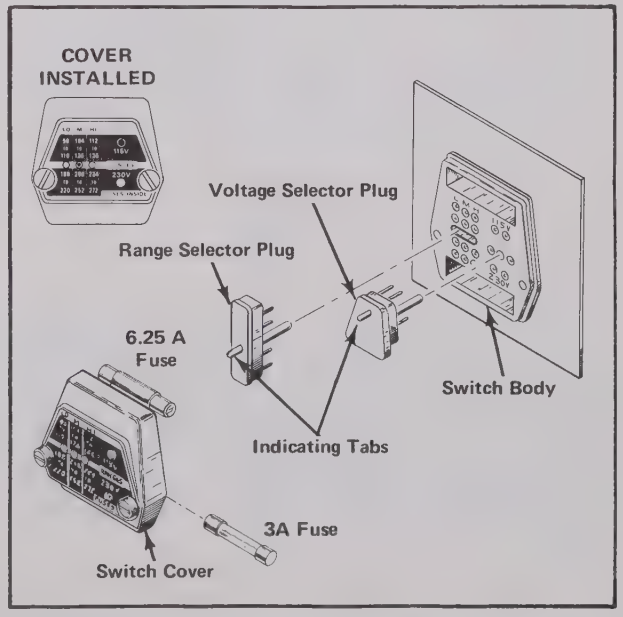


Fig. 2-1. Voltage Selector assembly. Oscilloscope serial number 8880 and above.

4. To change regulating ranges, pull out the Range Selector plug (see Fig. 2-1), slide it left or right to the desired position and plug it back in. Select a range which centers about the average line voltage to which the instrument is to be connected (see Table 2-1).

5. Re-install the cover and tighten the two captive screws, making sure that the indicating tabs are protruding through the correct holes in the cover for the desired line voltage and regulating range.

6. Re-connect the instrument to the power source.

CAUTION

Operation of this instrument with the Voltage Selector or Range Selector switch in the wrong position for the applied line voltage may damage the instrument or cause improper operation.

TABLE 2-1

Regulating Ranges, SN 8880 and Above

Range Selector Switch Position	Voltage Selector	
	115-Volts Nominal	230-Volts Nominal
LO (switch bar in left holes)	90 to 110 volts	180 to 220 volts
M (switch bar in middle holes)	104 to 126 volts	208 to 252 volts
HI (switch bar in right holes)	112 to 136 volts	224 to 272 volts

SN 8879 and Below

Unless otherwise indicated, the Type RM545B is shipped with the power transformer and fan wired for 115-volt AC input. Fig. 2-2 and a connection diagram on the side of the transformer show alternate connections for other input voltages to the power transformer. When the transformer is changed from 108-122 volts to 216-244 volts connection, the fan wiring must also be changed. Fig. 2-3 shows the fan connections for each voltage range.

The oscilloscope will regulate with input line voltages which are within 10% of designed center voltage range.

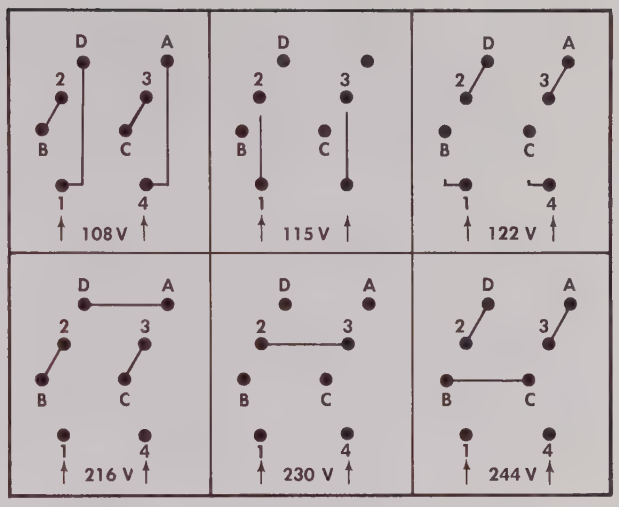


Fig. 2-2. Transformer connections for 108 to 244 volts, 50 to 60 Hz (and 400 Hz Operation when used with mod 101M).

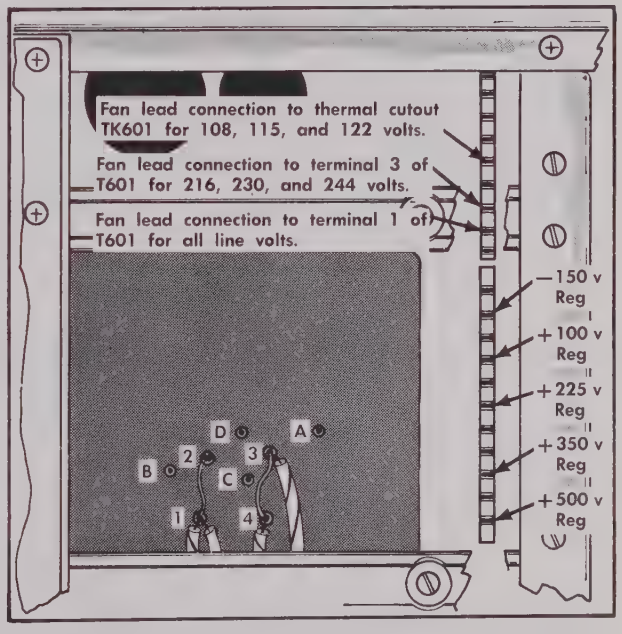


Fig. 2-3. Fan connection for 108 to 244 volts.

LIGHT FILTER

The light filter provided with the Type RM545B minimizes undesirable reflections when viewing the display under high ambient light conditions. The filter may be left on when taking waveform photographs unless a high writing rate is required.

If the light filter is removed, the CRT protector plate should be installed to prevent scratches to the CRT face plate.

CONTROLS AND CONNECTORS

A brief description of the function or operation of the front- and rear-panel controls and connectors is provided here. More detailed information on the use of specific controls is given in this section under First-Time Operation.

NOTE

Functions explained pertain to both the A and B horizontal time bases controls, whenever duplicate controls exist.

Beam Position — Four neon lamps (right-top of oscilloscope) with accompanying arrows indicate direction when the display is deflected out of the viewing area.

INTENSITY — Controls brightness of the display.

FOCUS — Used in conjunction with the INTENSITY and ASTIGMATISM controls for obtaining a well defined display.

ASTIGMATISM — Used in conjunction with the INTENSITY and FOCUS controls for obtaining a well-defined display.

TRACE ROTATION — Permits alignment of the trace with respect to the horizontal lines of the graticule. The TRACE ROTATION control is a screwdriver adjustment concentric with the ASTIGMATISM control.

SCALE ILLUM — Varies illumination of the graticule grid lines.

TRIGGERING LEVEL — Selects the amplitude point on the triggering signal where sweep-triggering occurs. Disabled when TRIGGERING MODE switch is at AUTO.

STABILITY — Adjusts the oscilloscope for a stable displayed waveform. The STABILITY control can be set to the PRESET position and left there. This position provides for convenient triggering since only the TRIGGERING LEVEL control needs to be adjusted to obtain a stable display. Disabled when TRIGGERING MODE switch is at AUTO.

TRIGGERING MODE — AUTO: Permits normal triggering on simple waveforms with repetition rates higher than about 50 Hz. With no trigger signal, or with a lower repetition rate, the trigger circuit free runs at approximately 40 Hz and triggers the time base at this rate, providing a reference trace.

AC LF REJ: Attenuates trigger-signal frequencies below about 17 kHz, allowing the trigger circuit to respond only to higher frequencies.

AC: Blocks the DC component of the triggering signal and allows triggering to take place only on the changing portion of the signal. For best triggering at high frequencies, use an AC coupling position of the TRIGGERING MODE switch.

DC: Permits triggering on both high- and low-frequency (to DC) signals. For frequencies below about 30 Hz, use the DC position.

TRIGGER SLOPE — Determines whether the time base is triggered on the negative- (–) or positive (+) going slope of the signal.

LINE: Uses a line-frequency signal as a trigger.

INT: Uses a portion of the signal applied to the vertical deflection plates of the CRT as a trigger signal.

EXT: Provides external triggering on a signal applied to the TRIGGER INPUT connector.

TIME/CM — Selects the time-base sweep rate.

VARIABLE (Time Base A) — Provides an uncalibrated sweep rate adjustment. The sweep rate can be slowed by a factor of at least 2.5X. An UNCALIBRATED lamp lights when the VARIABLE control is not in the

LENGTH (Time Base B) — Controls the length of the B sweep.

POWER ON — Toggle switch for turning the instrument power on and off.

VERT SIG OUT — Vertical signal output connector. Output amplitude is approximately 1.2 volts/cm of deflection.

TRIGGER INPUT — Connector for applying an external trigger signal to the selected time base; its TRIGGER SLOPE switch must be set to the EXT position to accept the signal.

HORIZ INPUT — Jack for applying external horizontal signal when the HORIZONTAL DISPLAY switch is set to either EXT X1 or X10.

VARIABLE 10-1 — Potentiometer for internally modifying the size of HORIZ INPUT signal.

DLY'D TRIG — Supplies a sharp positive-going trigger spike of at least 5 volts at the end of the delay period as set by the TIME/CM OR DELAY TIME switch and the DELAY-TIME MULTIPLIER dial.

+GATE B — Supplies an approximately 20-volt rectangular pulse when Time Base B is operating. Pulse duration is approximately 10.5X the setting of the TIME/CM OR DELAY TIME switch.

+GATE A — Same as +GATE B except applies to TIME BASE A.

SAWTOOTH A — Makes the Time Base A sawtooth voltage available externally. Peak amplitude is about +130 volts.

CRT CATHODE SELECTOR (rear panel) — Provides blanking of between-channel switching transients (in the CHOPPED BLANKING position) when using multi-channel plug-in units in the chopped mode. The CRT CATHODE SELECTOR switch should always be in the EXTERNAL CRT CATHODE position except when using the chopped mode.

EXTERNAL CRT CATHODE — With the ground strap disconnected, this connector applies Z-axis modulation signals to the CRT cathode. The Z-axis signals should be at least 20 volts in amplitude to cause intensity modulation. Always have the ground strap connected except when applying Z-axis modulation signals.

HORIZONTAL DISPLAY — A: Allows only Time Base A to appear on the CRT.

B: Allows only Time Base B to appear on the CRT.

'B' INTENSIFIED BY 'A': One of the delayed sweep functions. In this position, a portion of Time Base B is intensified during the time that Time Base A (the delayed sweep) is in operation.

'A' DLY'D BY 'B': One of the delayed sweep functions. In this position, Time Base A is displayed at the end of each delay period as determined by the B TIME/CM OR DELAY TIME and DELAY-TIME MULTIPLIER controls.

'A' SINGLE SWEEP: Allows the Time Base A generator to sweep once upon receipt of trigger signal and not sweep again until the circuit has been reset with the RESET button. Single sweep permits photographing non-repetitive waveforms, which otherwise would not be photographed clearly.

EXT X1 and X10: Permit an external signal to be applied to the horizontal deflection circuit. Sensitivity is continuously variable (with the VARIABLE 10-1 control).

READY Lamp — Lights when time-base circuit is ready for triggering after being reset.

HORIZONTAL POSITION and VERNIER — Positions the display along the horizontal axis of the CRT.

DELAY-TIME MULTIPLIER 1-10 — Works in conjunction with the Time Base B TIME/CM OR DELAY TIME switch. Varies sweep delay from 0 to 10 times the rate indicated by the Time Base B TIME/CM OR DELAY TIME switch.

5X MAGNIFIER	Expands the sweep by a factor of 5 at any setting of the TIME/CM switch. The center of expansion is the center of the graticule.
AMPLITUDE	Determines the peak-to-peak voltage of the square wave available at the CAL OUT connector.

SELECTION OF PLUG-IN UNITS

The Type RM545B is designed to use Tektronix letter-series and 1-series plug-in units as the input stage for the vertical deflection system.

The use of plug-in units for vertical input permits easy change of the vertical deflection characteristics to meet a wide range of application requirements. To convert the oscilloscope from one type measurement to another, the operator needs only to exchange the plug-in unit.

In selecting the plug-in units, consider the bandpass, risetime, deflection factor, input RC characteristics and the number of inputs desired. Other plug-in units to be considered are special purpose types such as differential amplifiers and comparators, operational amplifiers, spectrum analyzers, etc. Consult the Tektronix Catalog, specific plug-in manuals or the Field Engineer for information regarding plug-in units which can be used with the Type RM545B.

FIRST-TIME OPERATION

General

The following procedure is suggested for becoming familiar with the controls and basic operation of the Type RM545B. This procedure will permit the oscilloscope to display the calibrator waveform and provide a check of the FOCUS and ASTIGMATISM control settings. It also describes the checking and adjustment of the TRACE ROTATION control.

Preliminary Procedure

Check that the oscilloscope voltage input connections agree with the voltage with which the oscilloscope is to be used. Install an appropriate vertical plug-in unit in the oscilloscope, set the INTENSITY control fully counterclockwise, connect the oscilloscope to the line voltage for which the instrument is wired, and set the POWER switch to ON. While the instrument and plug-in unit are warming up, set the front-panel controls as follows:

TABLE 2-2

CRT Controls	
FOCUS	Midrange
ASTIGMATISM	Midrange
SCALE ILLUM	Counterclockwise
Triggering Controls (both A and B)	
TRIGGERING LEVEL	Clockwise (+)
STABILITY	Counterclockwise (PRESET)
TRIGGERING MODE	AUTO
TRIGGER SLOPE	+INT
Time/cm Controls	
A TIME/CM	.5 mSEC
VARIABLE	Clockwise (CALIBRATED)
B TIME/CM or DELAY TIME	.5 mSEC
LENGTH	Clockwise
HORIZONTAL DISPLAY	A
5X MAGNIFIER	OFF
DELAY-TIME MULTIPLIER 1-10	5.00
HORIZONTAL POSITION and VERNIER	Midrange
AMPLITUDE CALIBRATOR	.1 VOLTS
Vertical Plug-In Unit	
Position	Centered
Volts/Cm	.05
Input Selector	AC
Rear Panel	
CRT CATHODE SELECTOR	EXTERNAL CRT CATHODE

1. Connect the CAL OUT signal to the plug-in Input Connector with a BNC cable.

2. Advance the INTENSITY control until the display is at desired brightness level.

3. Adjust the FOCUS and ASTIGMATISM controls to obtain a sharp (well-defined) display.

4. Using the oscilloscope HORIZONTAL POSITION control, set the display to start at the first graticule line at the left. The display should be a square wave, 2 cm in height, with approximately five cycles occurring across the 10 cm graticule width.

Center the display vertically with the plug-in unit vertical Position control.

5. Set the AMPLITUDE CALIBRATOR to OFF. Check that the trace is parallel to the graticule center line (re-position the trace vertically as necessary). If the trace tilts to the right or left, insert a small bladed screwdriver into the hole in the ASTIGMATISM knob and adjust the TRACE ROTATION control for parallelism with the graticule horizontal center line.

Normal Non-Delayed Sweep

The Type RM545B Oscilloscope features two independent time base circuits: Time Base A and Time Base B.

Sweep Triggering

To present a stable display of a recurring waveform (or periodic function) each must start at (or be triggered) at the same point on the recurring waveform. Thus, the sweep must be triggered by the input signal or by some external signal that has a fixed time relationship with the displayed signal. The external trigger signal must be the same frequency, a multiple or a sub-multiple of the input signal.

Selecting the Trigger Source

The TRIGGER SLOPE switch selects one of a variety of possible triggering signals. For most applications, the sweep can be triggered internally from the displayed signal. This occurs with the TRIGGER SLOPE switch set at either + or — INT.

The LINE positions of the TRIGGER SLOPE switch connect the AC power source line-frequency signal to the triggering input. Line triggering is useful whenever the input signal is frequency-related to the line signal.

To trigger the time base from an external signal, set the TRIGGER SLOPE switch to an EXT position and connect the trigger signal to the TRIGGER INPUT connector. External triggering is often used when signal tracing in amplifiers, phase-shift networks, and wave-shaping circuits. The signal from a single point in the circuit can be used as an external trigger signal. With this arrangement, it is possible to observe the polarity, shaping and/or amplification of a signal at various points through the circuit without resetting the triggering controls for each new display.

Selecting Triggering Mode

Four means of trigger coupling are available with the TRIGGERING MODE switch. The different coupling positions permit acceptance or rejection of certain frequency components of the triggering signal.

With the switch set at DC, the time base can be triggered with all frequency components of the triggering signal within the trigger amplifier bandpass, including changes in DC levels.

With the switch set at AC LF REJ, DC and low-frequency signals (below about 17 kHz) are rejected or attenuated. Thus, the trigger circuit will respond best to the higher-frequency components of the triggering signal.

With the switch set to AUTO, proper triggering automatically takes place in response to many input signals. When the triggering signal is being applied, or when the frequency of the triggering signal is lower than the repetition rate of the AUTO trigger circuit, the trigger circuit free runs at approximately 40 Hz. The time base is then triggered at this 40 Hz rate to provide a reference trace.

In general, use AC trigger coupling. However, it will be necessary to use DC coupling for very low-frequency signals. When line-frequency ripple is mixed with the triggering signal it is best to use AC LF REJ coupling so that triggering takes place only on the signal of interest (if the signal of interest contains frequency components above about 17 kHz).

The AC LF REJ position is also useful when triggering internally from multi-channel plug-in units operated in the alternate dual-trace mode. AC LF REJ coupling has a faster recovery time than AC coupling when subjected to the alternate DC levels from the multi-channel plug-in unit.

Selecting Trigger Slope

The TRIGGER SLOPE switch determines whether the triggering circuit responds on the rising (+ setting) or the falling (— setting) portion of the triggering signal. When several cycles of a signal appear in the display, the setting of the TRIGGER SLOPE switch will probably be unimportant. However, if you wish to look at only a certain portion of a cycle, the TRIGGER SLOPE switch permits starting the display on the desired slope of the input signal. Fig. 2-4 illustrates the effect of both the TRIGGER SLOPE and TRIGGERING LEVEL controls.

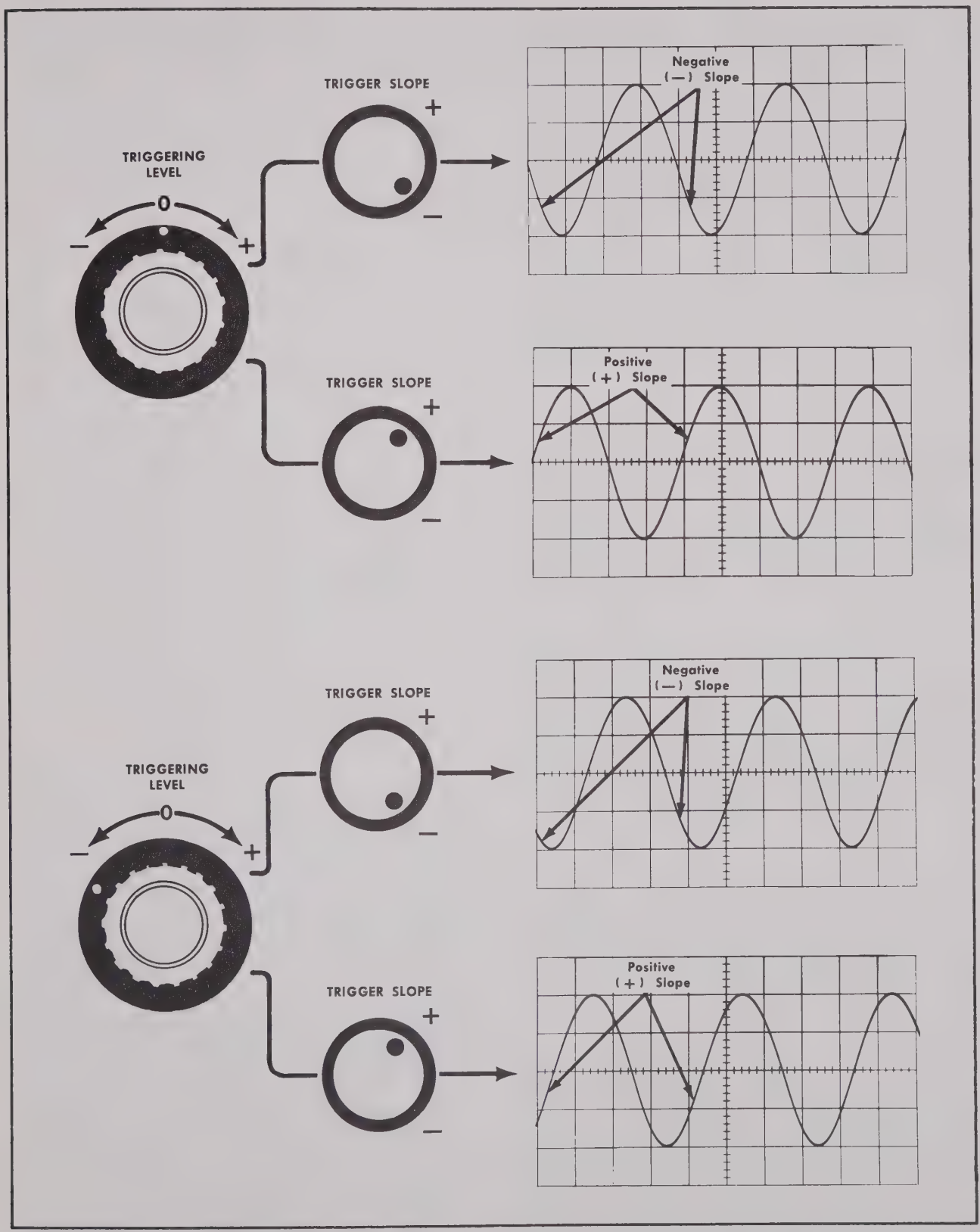


Fig. 2-4. Effects on the oscilloscope display produced by + and — settings of the TRIGGERING LEVEL control. When the TRIGGERING LEVEL control is set in the + region, the sweep is triggered on the upper portion of the input waveform; when it is set in the — region, the sweep is triggered on the lower portion of the input waveform. The TRIGGER SLOPE control determines whether the sweep is triggered on the rising portion or the falling portion of the input waveform.

Setting Stability Control

The STABILITY control has no effect when the TRIGGERING MODE switch is at AUTO. In nearly all other triggering applications, satisfactory operation can be obtained with the STABILITY control in the PRESET (fully counterclockwise) position. The PRESET position has the advantage of requiring no further adjustment of the STABILITY control when switching from one triggering signal to another. However, if stable triggering becomes difficult with the STABILITY control at PRESET, it will be necessary to adjust the control for proper triggering. To adjust the STABILITY control, place the TRIGGERING LEVEL control in the fully counterclockwise position, then turn the STABILITY control clockwise until a trace appears on the CRT. The correct setting is obtained by turning the control counterclockwise three to five degrees from the point where the trace appears.

Setting Triggering Level

The TRIGGERING LEVEL control is disabled when the TRIGGERING MODE switch is at AUTO. In other positions of the TRIGGERING MODE switch, the TRIGGERING LEVEL control determines the amplitude point on the signal where triggering occurs.

The trigger circuit is most sensitive to AC triggering signals with the TRIGGERING LEVEL control set near zero. Setting the TRIGGERING LEVEL control in the + zone causes the trigger circuit to respond at a correspondingly positive amplitude on the triggering signal. Setting the TRIGGERING LEVEL control in the – zone causes the trigger circuit to respond at a correspondingly negative amplitude on the triggering signal.

Selecting Time/Cm (Sweep Rate)

The TIME/CM and 5X MAGNIFIER switches control the sweep rate. The 5X MAGNIFIER switch expands both time bases. The two switches therefore permit viewing an applied signal at a wide variety of sweep rates.

When the 5X MAGNIFIER switch is OFF, the TIME/CM switch indicates the true sweep rate. However, with the 5X MAGNIFIER switch ON, the setting of the TIME/CM switch must be divided by 5 to determine the true sweep rate. For example, assume that the TIME/CM switch is at 1 mSEC and the 5X MAGNIFIER is ON. In this case the true sweep rate would be 1 mS ÷ 5 (5X MAGNIFIER setting) resulting in a displayed sweep rate of 0.2 mS/div, Fig. 2-5 illustrates how to make time measurements from the graticule.

Only CALIBRATED readings can be obtained from the B time base. The A time base has a variable control which (in conjunction with the A TIME/CM switch and the 5X MAGNIFIER) makes a continuous range of uncalibrated time bases available from .02 μs/cm (TIME/CM at .1 mSEC, 5X MAGNIFIER ON, VARIABLE at CALIBRATED) to at least 12 1/2 seconds per cm (TIME/CM at 5 seconds, 5X MAGNIFIER off, VARIABLE fully counterclockwise).

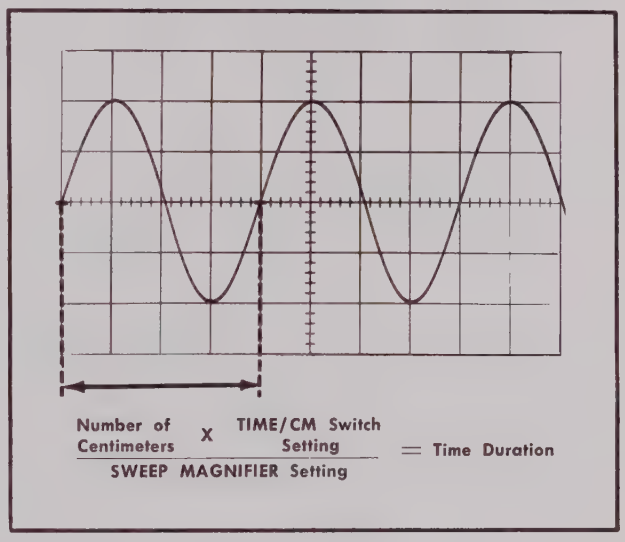


Fig. 2-5. Time measurement from the graticule.

Single-Sweep Operation

In applications where the displayed signal is not repetitive (or varies in amplitude, shape, or time), a photograph of a conventional repetitive display may produce a jumbled presentation. To avoid this, use the single-sweep feature of the Type RM545B to photograph the display. To use single sweep, first make sure the trigger circuit will trigger on the event you wish to display. Do this in the conventional manner with the HORIZONTAL DISPLAY switch set to 'A'. Then, after setting the HORIZONTAL DISPLAY switch to 'A' SINGLE SWEEP, press the RESET switch and release. When this is completed, the next trigger pulse will actuate the sweep and the Type RM545B will display a single trace of the event. The READY lamp (near the HORIZONTAL DISPLAY switch) first lights when the sweep is ready to accept a trigger and then goes out after triggering has taken place. To ready the circuit for another single display, press the RESET switch and release. In single-sweep operation, make sure the TRIGGER MODE switch is not set to AUTO.

Non-Triggered Delayed Sweep

The following procedures describe various measurements and their accuracy, and other operations that can be performed using delayed sweep.

Insert a vertical plug-in unit and set the controls and switches on the instruments as listed in Table 2-3.

TABLE 2-3

B TRIGGERING MODE	AC
B TRIGGER SLOPE	+INT
B TRIGGERING LEVEL	0
B STABILITY	Fully clockwise
B TIME/CM or DELAY TIME	1 mSEC
B LENGTH	Fully clockwise
A TRIGGERING MODE	AC
A TRIGGER SLOPE	+EXT
A TRIGGER LEVEL	0
A STABILITY	Fully clockwise
A TIME/CM	.1 mSEC
VARIABLE	CALIBRATED
HORIZONTAL DISPLAY	'B' INTENSIFIED BY 'A'
SWEEP MAGNIFIER	OFF
DELAY-TIME MULTIPLIER	5.00
AMPLITUDE CALIBRATOR	10 Volts
HORIZONTAL POSITION	Centered
INTENSITY	So both intensity levels in the trace are easily seen.

Set the applicable controls and switches of the vertical plug-in unit as follows:

Volts/Div	20
Variable	Calibrated
AC-DC-GND	DC
Position	Trace centered

Set the HORIZONTAL POSITION control so the trace begins precisely at the first vertical line at the left-hand edge of the graticule. Notice the position of the intensified segment in the trace.

Now set the TIME/CM OR DELAY TIME switch to .1 SEC and A TIME/CM switch to .2 SEC. The intensified segment should be at the same position as with the previous sweep rates.

Using the vertical plug-in unit Position control, set the trace to the bottom graticule line. Connect the SAWTOOTH A output to the vertical plug-in unit input. Notice that the A sweep sawtooth and the intensified segment in the trace start and end at the same time. This display shows that Time Base A produces one sweep during the intensified segment of each B sweep.

The B sweep rate is 0.2 s/cm. The intensified segment begins 5 cm after the beginning of the trace. Hence, the A sweep starts 1 second after the B sweep (0.2 s/cm X 5 cm).

The number of centimeters between the beginning of the trace and the beginning of the intensified segment is established by the setting of the DELAY-TIME MULTIPLIER dial. Therefore, with any dial setting, the time difference between the beginning of the A and B sweeps is the product of the TIME/CM OR DELAY TIME switch and the DELAY-TIME MULTIPLIER dial setting (see Fig. 2-6).

Accuracy: Determined by the combination of all the following factors:

1. The basic accuracy of time measurements made by using the sweep delay is as stated in Section 1.

2. The Delay Pickoff and Time Base A generator circuits typically require a total of about 75 to 100 ns to respond to the signal event which triggers Delayed Sweep (A). This small inherent delay need not be considered unless it is a significant percentage of the measured time or when measuring time differences using the same sweep rate. When necessary, add the total circuit delay time to the measured time; that is, when measuring the time from the start of the B sweep.

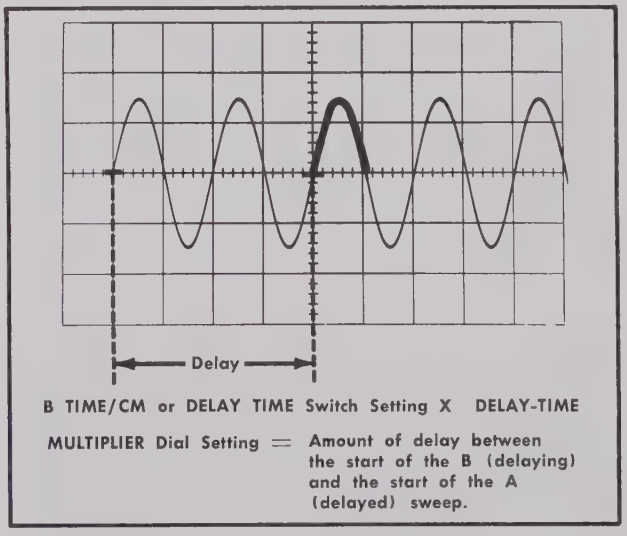

Delay
B TIME/CM or DELAY TIME Switch Setting X DELAY-TIME MULTIPLIER Dial Setting = Amount of delay between the start of the B (delaying) and the start of the A (delayed) sweep.

Fig. 2-6. Determining delay time.

The following information describes several typical applications of the delayed sweep feature. These applications provide more accurate measurements than time measurements which are made by using a single time base.

Demonstration 1

This procedure describes how to measure pulse duration with the pulse triggering Time Base B.

Set the controls and switches as listed in Table 2-3 except as follows:

B TIME/CM OR DELAY TIME	.2 mSEC
A TIME/CM	.5 μSEC

Apply the AMPLITUDE CALIBRATOR signal to the input of the vertical plug-in unit. Adjust the B triggering controls to obtain a stable display. The display should consist of approximately 2 cycles of the square-wave signal.

Turn down the intensity until the brightened portion of the trace is easily distinguished. Using the DELAY-TIME MULTIPLIER knob, position the brightened portion of the trace to the falling portion of the square wave which is nearest the left edge of the graticule. Record the setting of the DELAY-TIME MULTIPLIER dial. Now position the brightened portion to the next falling portion of the square wave. Again record the setting of the DELAY-TIME MULTIPLIER dial.

Subtract the first DELAY-TIME MULTIPLIER dial setting from the second and multiply the result by the setting of the TIME/CM OR DELAY TIME switch. The figure obtained is the time interval between the points measured. In this case it is the period time for 1 cycle of the AMPLITUDE CALIBRATOR waveform.

Accuracy. The method described in Demonstration 1 provides a time measurement accuracy within 1% of reading, ±2 minor divisions of the DELAY-TIME MULTIPLIER dial.

Demonstration 2

This procedure describes how to measure time between two pulses, neither of which triggers Time Base A.

Set the controls and switches as listed in Table 2-3 except as follows:

B TIME/CM OR DELAY TIME	.2 mSEC
A TIME/CM	2 μSEC

Apply the AMPLITUDE CALIBRATOR signal to the vertical input. Adjust the B triggering controls to obtain a stable display. The display should consist of about 2 cycles of the square wave. Turn down the intensity until the brightened portion of the trace is easily distinguished. Set the DELAY-TIME MULTIPLIER dial so the square-wave rise located near the center of the display is intensified.

Using the DELAY-TIME MULTIPLIER dial, position the start of the brightened portion to the 50% point on the square-wave rise. Record the setting of the DELAY-TIME MULTIPLIER dial. Now position the start of the brightened portion of the trace to the 50% point of the falling portion of the same half cycle. Again record the setting of the DELAY-TIME MULTIPLIER dial.

Subtract the first dial setting from the second setting. The product of the difference times the TIME/CM OR DELAY TIME switch setting equals the time duration of the square-wave positive-going half cycle (between the 50% amplitude points). This measurement should indicate a time of about 0.5 ms.

Accuracy. Determined by the combination of the following factors:

1. The basic accuracy of the sweep delay as described in Demonstration 1.

2. The error added by the sweep-delay system linearity is ±2 minor dial divisions. Hence, percentage of measurement error decreases as the numerical dial difference increases.

NOTE

When the separation between dial settings is 100 minor dial divisions or less, the time measurement can often be made more accurate by direct reading from a magnified CRT display. See Demonstration 3: Magnification.

3. The accuracy of time measurement made in Demonstration 2 is independent of the inherent circuit delays, provided the B TRIGGERING LEVEL control setting is the same for each of the two dial readings.

Demonstration 3

Complex signals contain a number of individual events of different amplitudes. Since the trigger circuits of the Type RM545B respond to signal amplitude, a stable display will normally be obtained only when the sweep is triggered by the event having the greatest amplitude. The A delayed by B mode permits the start of the A sweep to be delayed for a selected time after the signal event having the greatest amplitude. Any event within the series of events may then be displayed in magnified form as follows:

Set the controls and switches on the instrument as listed in Table 2-3. Apply the AMPLITUDE CALIBRATOR signal to the vertical input. If necessary, adjust the B triggering controls to obtain a stable display. This display should consist of several cycles of the square-wave signal. Set the DELAY-TIME MULTIPLIER dial to intensify one of the positive-going pulses.

Set the HORIZONTAL DISPLAY switch to 'A' DLY'D BY 'B'. The display now should include the same signal information as the intensified trace segment, but horizontally expanded (magnified) ten times.

Increase the A sweep rate to 1 μs/div. The INTENSITY control may require readjustment. Set the DELAY-TIME MULTIPLIER dial to position a square-wave rise on the CRT. The display now gives X1000 magnification of the intensified segment.

Slowly turn the DELAY-TIME MULTIPLIER dial. Note that any portion of the square wave can be brought into view in magnified form.

The DELAY-TIME MULTIPLIER dial reading corresponds to the number of centimeters between the beginning of the Time Base B trace and the beginning of the Time Base A (intensified) trace (e.g. 7.00 = 7 major graticule divisions).

The A delay display will probably exhibit some horizontal jitter. The time jitter contributed by the delay system is less than 5×10^{-4} times the TIME/CM OR DELAY TIME switch setting. Since the sweep rate of the delayed sweep is now 1 μs/cm, the jitter due to the delay system is less than one-half centimeter.

Accuracy: Depends solely on the B sweep-rate accuracy as listed in Section 1.

Demonstration 4

Ordinarily, the displayed signal is also used to trigger the oscilloscope sweep. In some situations, it may be desirable to reverse this situation. The sweep-related output pulses, available from the front-panel of the Type RM545B, can be used as a triggering signal for an external device. The output signal of the external device can then produce a stable display while the oscilloscope sweep free runs.

To demonstrate one method of performing this operation proceed as follows:

Set the controls and switches as listed in Table 2-3, except as follows:

A TIME/CM	10 μSEC
HORIZONTAL DISPLAY	A

Connect a lead from the DLY'D TRIG connector to the vertical input. A positive-going spike should appear on the trace.

The oscilloscope display is the pulse that is available at the DLY'D TRIG connector at the end of each delay period. In a practical application, the pulse would not be applied to the vertical input but instead to some external device to be tested. The pulse would then serve as the trigger pulse or input signal to the external device, and the output of the device would provide a stable display on the oscilloscope, as though the oscilloscope were triggered in the normal manner. The position of the displayed signal along the oscilloscope trace is determined by the setting of the DELAY-TIME MULTIPLIER dial.

Disconnect the lead from the DLY'D TRIG output jack.

Demonstration 5

The +GATE B connector output signal can be used as a variable repetition rate, variable duty-factor pulse generator. To use the Type RM545B in this manner, Proceed as follows:

Set the controls and switches as listed in Table 2-3 except as follows:

HORIZONTAL DISPLAY	B
B TRIGGERING MODE	AUTO

Using another oscilloscope, monitor the signal avialable at the +GATE B jack, and establish the desired pulse repetition rate by setting the TIME/CM OR DELAY TIME switch. Establish the desired duty cycle factor by setting the LENGTH control.

The +GATE A signal can be used in the same manner except that its duty cycle and pulse repetition rate can be changed simultaneously by the VARIABLE control.

Triggered Delay Sweep

Complex signals contain a number of individual events at different amplitudes. Since the trigger circuits in the Type RM545B respond to signal amplitude, a stable display will normally be obtained only when the sweep is triggered by the event having the greatest amplitude.

The following instructions demonstrate that Time Base A can be triggered by any event within a series of events, regardless of relative amplitude.

Set the controls and switches on the instrument as listed in Table 2-3.

Connect the AMPLITUDE CALIBRATOR signal to the vertical input. Using the B triggering controls, obtain a stable display.

Turn the DELAY-TIME MULTIPLIER dial about 2 turns in either direction. Notice that the brightened segment in the display moves smoothly across the CRT.

Set the DELAY-TIME MULTIPLIER dial so the brightened segment begins about in the middle of the pulse top which immediately follows the vertical center-line on the graticule. Now turn the HORIZONTAL DISPLAY switch to A and the Time Base A TRIGGER SLOPE switch to +INT. Using the A triggering controls, obtain a stable display. Return the HORIZONTAL DISPLAY switch to 'B' INTENSIFIED BY 'A'. Notice that the brightened segment in the display has shifted to the next pulse on the right. (If the brightened segment is not present, or is unstable, readjust the A triggering controls.) Turn the DELAY-TIME MULTIPLIER dial several full turns. The brightened segment in the display should jump from one pulse to the next. Set the HORIZONTAL DISPLAY switch to 'A' DLY'D BY 'B' and note that the display now begins on the rising portion of the pulse. With the present display, turning the DELAY-TIME MULTIPLIER dial should not change the display since all of the AMPLITUDE CALIBRATOR pulses are the same shape. However, if the input signal consisted of a repeating series of several dissimilar pulses, turning the dial would provide a triggered display of each pulse in the series, providing that the A triggering controls are set for triggering on the smallest pulse.

The 'A' DLY'D BY 'B' display is produced in the following manner.

Time Base A produces one sweep during each B sweep. The Time Base A sweep will begin some time after the start of B sweep. This time is the total of the TIME/CM OR DELAY TIME switch setting multiplied by the DELAY-TIME MULTIPLIER dial setting, plus the time between the end of this delay interval and the next event in the signal which can trigger Time Base A.

With the A triggering control set for triggered operation, the Time Base A sweep will occur only if A is armed and triggered before the B sweep ends.

External Horizontal Deflection

For special applications, horizontal deflection can be produced with an externally derived signal. Thus, the oscilloscope system can be used to plot one function against another (e.g. Lissajous figures). However, the system is not intended for precise phase-angle measurements.

To use an external signal for horizontal deflection, connect the signal to the HORIZ INPUT connector. Set the HORIZONTAL DISPLAY switch to EXT X10 or X1. The signal is DC coupled to the deflection amplifier. The 5X MAGNIFIER switch is inoperative when the HORIZONTAL DISPLAY switch is set to either external horizontal position.

Dual-Trace Chopped Blanking

Multi-trace plug-in units which provide as high as four separate traces on the CRT are available. These traces permit a corresponding number of separate functions to be displayed simultaneously. Detailed instructions for operating a multi-channel plug-in unit in conjunction with the Type RM545B Oscilloscope are contained in the plug-in unit instruction manual.

When the multi-channel plug-in unit is operated in the chopped mode to obtain a dual-trace presentation, switching transients will be displayed on the CRT. These switching transients can be reduced by placing the CRT CATHODE SELECTOR switch at the rear of the Type RM545B in the CHOPPED BLANKING position.

Intensity Modulation

The Type RM545B CRT display can be intensity modulated by the external signal to display additional information. This is done by disconnecting the grounding bar from the EXTERNAL CRT CATHODE connector at the rear of the instrument and connecting the external signal to this terminal. The CRT CATHODE SELECTOR switch must be in the EXTERNAL CRT CATHODE position.

Very accurate time measurements can be made by intensity modulating the beam with time markers and measuring directly from the time markers on the CRT. A positive signal of approximately 20 volts is required to cut off the beam from normal intensity. The low-frequency cutoff point for Z-axis modulation is 600 Hz.

NOTES

SECTION 3
CIRCUIT DESCRIPTION

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

A simplified description is provided first to explain the purpose of each major circuit. This is followed by detailed descriptions of individual circuits.

SIMPLIFIED DESCRIPTION

Low-Voltage Power Supply

The low-voltage power supply produces all operating voltages for the oscilloscope with the exception of parts of the CRT circuit. The low-voltage supply provides regulated −150, +100, +225, +350 and +500 volts. It also provides filament voltages and an unregulated +325-volt output.

Vertical Plug-In Preamplifier

Refer to the oscilloscope Block Diagram at the back of this manual. The Vertical Plug-In Preamplifier consists of any Tektronix letter- or 1-Series plug-in unit. For additional information, refer to the applicable plug-in manual.

Vertical Amplifier

Vertical Input Amplifier. The vertical Input Amplifier is a balanced hybrid circuit that amplifies the output of the vertical preamplifier plug-in. It then applies the signal through the Delay Line to the vertical Output Amplifier and the Trigger Pickoff circuit.

Delay Line. The push-pull output of the vertical Input Amplifier is applied through the balanced Delay Line to the vertical Output Amplifier. The Delay Line is a specially braided 186 Ω line which delays the application of the vertical signal to the vertical Output Amplifier for about 200 ns. This provides time for unblanking the CRT and starting the horizontal sweep before the vertical signal reaches the deflection plates. The delay allows the leading edge of a single fast-rising pulse to be displayed. The delay line requires no adjustment.

Vertical Output Amplifier. The vertical Output Amplifier is a push-pull cascode amplifier that takes the output of the Delay Line and converts it to a drive signal which is applied to the vertical deflection plates of the CRT.

Trigger-Pickoff Circuit. The Trigger Pickoff circuit applies a sample of the input waveform to the trigger circuits of both time bases. The trigger is picked off at the output of the vertical Input Amplifier.

Time Base A Trigger

The Time Base A Trigger circuit develops triggers which initiate development of ramp voltages in the A Sweep Generator circuit. Triggers occur in response to any one of the following: internal signals from the Vertical Amplifier; external signals applied to the TRIGGER INPUT connector; line voltage signals derived internally from the power supply transformer; automatic signals created by a free-running multivibrator in the Time Base A Trigger circuit.

Time Base A Generator

The Time Base A Generator provides accurate ramp voltages for the horizontal deflection system, unblanking for the CRT, a +GATE A and a sawtooth voltage signal to front-panel connectors. Ramps are normally triggered by signals from the Time Base A Trigger circuit, but can also be generated independent of the Trigger circuit at a free-running rate when selected by front-panel controls.

Time Base B Trigger

The Time Base B Trigger circuit supplies triggers to the Time Base B Generator circuit, operating in the same manner as the Time Base A Trigger circuit.

Time Base B Generator

The Time Base B Generator closely resembles the Time Base A Generator. The functions and the circuit description given for the Time Base A Generator, in most instances, also apply to the Time Base B Generator.

Delay Pickoff Circuit

The Delay Pickoff circuit compares either the A or B ramp voltage with the Delay-Time Multiplier variable reference voltage, and generates a trigger at a point selected by the front-panel DELAY-TIME MULTIPLIER setting. When compared against the B sweep ramp, the Delay Pickoff circuit provides delayed triggers for "arming" the A sweep circuit, and also provides delayed triggers to the DLY'D TRIGGER front-panel connector. When compared against an A sweep ramp, the Delay Pickoff circuit only provides delayed triggers to the DLY'D TRIGGER front panel connector.

Horizontal Amplifier

The input to the Horizontal Amplifier is selected from the outputs of the Time Base B Generator, Time Base A Generator, or the External Horizontal Amplifier. The selected input is converted to push-pull and amplified to provide push-pull drive to the CRT horizontal deflection plates.

External Horizontal Amplifier

The External Horizontal Amplifier provides the necessary gain to drive the Horizontal Amplifier from external signals. An input attenuator and a gain control provide horizontal deflection factors from about 0.2 to 15 volts/cm.

CRT Circuit

CRT Power Supply. The CRT Power Supply provides the high voltages for operating the CRT. The power supply uses a 50 kHz Hartley oscillator. Secondary windings on the oscillator transformer provide voltages to the high-voltage rectifiers.

Cathode-Ray Tube (CRT). The CRT is a flat-faced, internal graticule, 5-inch tube with 6 cm of usable vertical scan area. The deflection plates provide low-input capacitance and minimum x-axis center-to-edge defocusing.

Calibrator

The Calibrator is a multivibrator and cathode-follower circuit that provides a square-wave output with a maximum amplitude of 100 volts at approximately 1 kHz. A step attenuator permits front-panel switching of the signal amplitude.

CIRCUIT DESCRIPTION

Power Supply ◇1◇

Block Diagram Description. Refer to Fig. 3-1. The low-voltage power supply consists of five inter-related supplies that provide filtered and regulated −150, +100, +225, +350, and +500 volts. An unregulated voltage of +325 volts is also developed by the Power Supply circuit. A common power transformer (T601) provides input power to each of the supplies. Unless otherwise specified, instruments are shipped with T601 connected for 115-volt AC input power.

T601 and rectifier D642 deliver about 270 V to the −150 volt regulator circuit. A portion of this voltage is felt across R616 and applied to V624, where it is compared to a reference voltage provided by neon glow tube V609. In response, V634 applies a control voltage to series regulators V627, V637 and V647. When R616 is properly set, sufficient voltage is dropped across the series regulators to provide a −150-V output. Deviations from this voltage are sensed by R616. An error signal is then sent through V624 to change the voltage drop across the series regulators, keeping changes in the −150 V supply to a minimum.

The +100-V supply uses the −150-V supply as its reference. The voltage at the R650-R651 junction is applied to Error Amplifier V664, which develops a control signal to apply to Series Regulator V677A. The series regulator functions in the same manner as the −150-V series regulator.

The +325-V unregulated supply is obtained by combining (in series-aiding configuration) the approximately +180-V unregulated output of D672 with the output of D702 (about +145 V). The resultant +325 V (approximate) is used in the oscilloscope circuitry as an unregulated supply, and is also applied to series-regulators V677B and V737B to develop the +225-V regulated supply. The +225-V regulator differs from the +100-V regulator in the following ways: a non-inverting amplifier (V684) is added; two series regulators are used.

To obtain power for the regulated +350-V supply, D732 is combined with the D702-T601 circuitry in such a manner as to add approximately +300 V to the approximately +180 V unregulated output of D672 and its associated T601 winding. The resulting +480 V (approximate) is applied to the +350-V regulator circuit, which is essentially the same as the +100-V regulator.

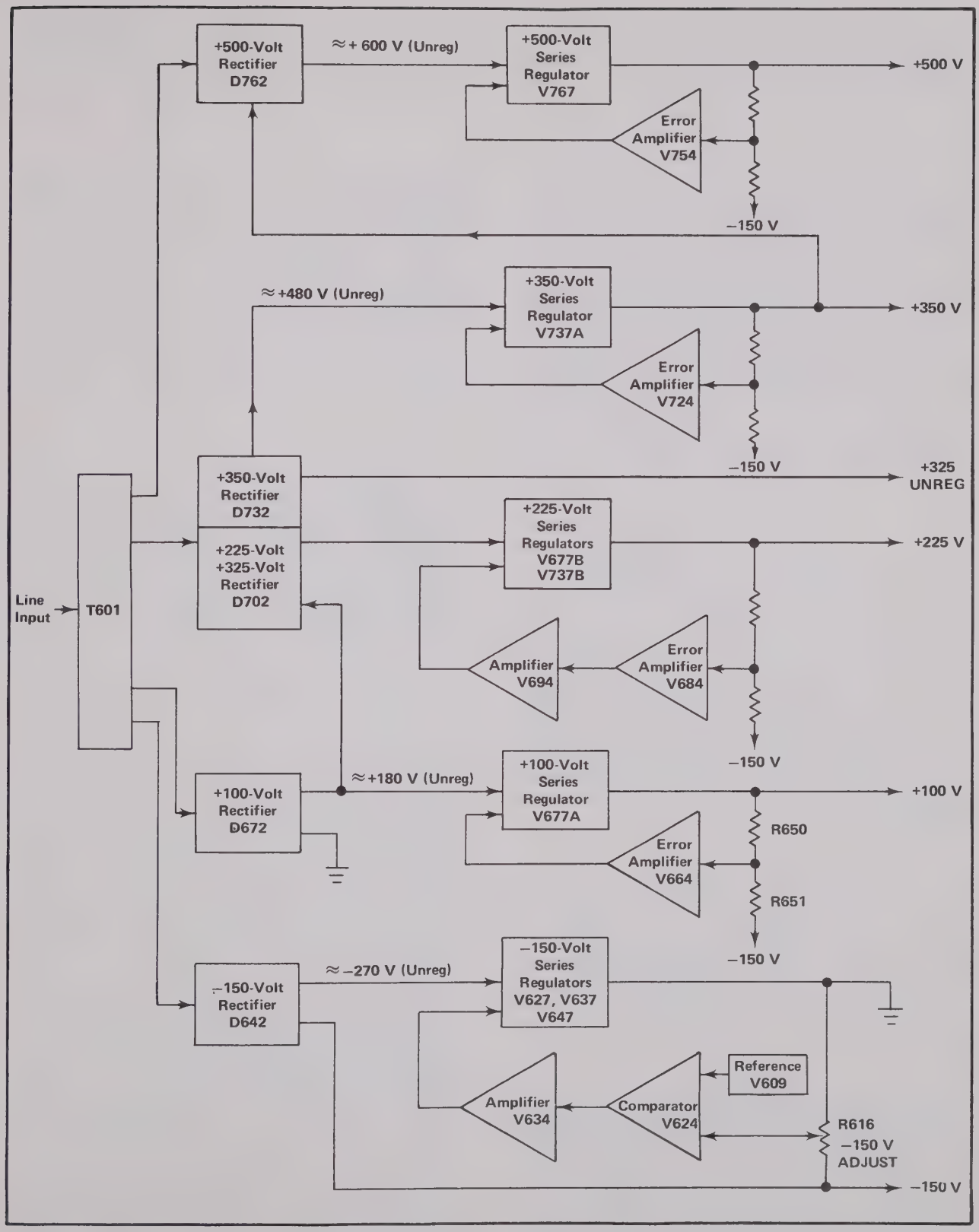


Fig. 3-1. Low VOLTAGE Power Supply simplified Block Diagram.

The output of D762 (approximately 250 V) is added to the regulated +350 V output. The combined voltage is applied to the +500 V regulator circuit, which is also similar to the +100 V regulator.

Detailed Description. Refer to the Power Supply schematic in the back of the manual. The 115-volt AC input power is applied to T601 through POWER ON switch SW601 and fuse F601. In instruments Serial Number 8880 and above, when 230 V operation is selected F602 is placed in series with F601, lowering the current limit to 3 A. Instruments below serial number 8879 use a different fuse as F601 in 230 V operation than is used in 115 V operation. In addition, when these instruments are wired for 115 V operation they continue to supply power to the fan after F601 opens up. In all other cases, a blown fuse removes power from all circuits. Thermal cutout TK601 (in the primary circuit of T601) is a protective device that opens the transformer primary circuit if the temperature inside the oscilloscope rises above a safe level. TK601 resets automatically when the temperature returns to normal.

Thermal time-delay relay K600 provides a filament warmup time of approximately 30 seconds before the DC power supplies are activated. The heater of K600 is rated at 6 volts and is connected to 6.3 volts on the T601 secondary winding. During heater warmup time, K600 contact 4 is disconnected from contact 9. At the end of warmup time, the circuit closes and applies power to magnetic relay K601. Contacts K601-1 remove the heater power from K600. Before K600 can open, contacts K601-1 lock the holding circuit to the coil of K601. K601 now remains energized until the power to the oscilloscope is switched off, or is otherwise interrupted. When K601 is energized, contacts K601-2, K601-3 and K601-4 close and activate their respective supplies.

The —150-volt supply is the reference voltage source for the other supplies and must be very stable. The —150-volt supply includes a high-gain electronic voltage regulator designed to give good regulation under extreme operating conditions. This regulator circuit contains a series regulator, a glow tube reference source, an error detector, and an amplifier.

The input power to the —150-V supply is provided by a secondary winding of T601. The AC voltage is rectified by silicon diode rectifier bridge D642 and filtered by C640. The negative side of D642 provides the —150-V output with respect to ground. The parallel combination of V627, V637, V647 and R647 exists between ground and the positive side of D642, providing series regulation for the —150-V supply.

Error sensing in the voltage-regulator circuit is accomplished by comparator V624. The voltage on the grid of V624A is held at approximately —85 volts by reference tube V609. V624B grid voltage is established by the setting of the tap on R616 in voltage divider R615, R616, R617.

Assume that the output voltage of the —150-V supply becomes more negative because of an increase in line voltage. The voltage increase appears on the cathodes of V624A and V624B and (through the tap on R616) on the grid of V624B. The voltage divider causes only a part of the voltage increase to appear between the grid and cathode of V624B, but the full change appears between the grid and cathode of V624A. V624A therefore becomes less biased than V624B, causing an increase in V624A conduction. This causes a positive change to occur at the plate of V624B.

The positive change in plate voltage is amplified and inverted to a negative change by amplifier V634. The amplified negative error signal from V634 is applied to the grids of series regulators V627, V637, V647, decreasing the current through the tubes. Their resistance and the voltage drop across them both increase. The voltage necessary ro provide the increased drop across the series regulator tubes can only be obtained by subtracting it from the negative side of the supply, so most of the undesired increase in negative voltage is developed across the series regulators and shunt resistor. Only enough change is felt in the —150-V supply to cause the regulating action to take place.

If the output of the —150-V supply becomes less negative, the error voltage applied to the grids of the series regulators is positive-going. This lowers the resistance of the regulators and the voltage drop across them decreases, leaving more voltage for the negative side of the supply. Since the output voltage of the —150-V supply depends upon the relationship between the voltage on the tap of R616 and the reference voltage from B609, R616 permits accurate adjustment of the output voltage.

Filter capacitor C640 aids the series-regulator in removing ripple from the output of the bridge rectifier. Any ripple between the —150-V output point and ground reaches the grid of V624B via C617. This input ripple voltage is amplified by V624 in the same manner as a signal. The ripple output voltage at the plate of V624B is coupled through C628 to the grid of V634 where it is further amplified, inverted and applied to the grids of the series regulator tubes with a polarity that causes the majority of the ripple voltage to be developed across the series regulators. Ripple in the positive side of the —150-V supply is coupled through R637 to the screen grid of V634. The screen grid

acts in consonance with the control grid in supplying the series regulators with ripple signal. R640 and R641 act as fusing resistors to protect against large surge currents. C649 filters only the −150-volt supply and suppresses voltage changes caused by sudden load changes.

The +100-V supply source is the output of a secondary winding of transformer T601 and silicon diode bridge D672. In addition to its other loads, the +100-volt supply provides current to a series filament string. When the instrument is turned on, open contacts of relay K601 hold all the regulated supplies inoperative. During this time, the series filaments are supplied by the unregulated side of the +100-V supply through the closed contacts of K601-3 and R675. By the time thermal relay K600 activates K601, the series filaments have reached operating temperature. K601-3 then switches and permits the regulated output of the +100-volt supply to provide filament power.

V664 is the +100-V error amplifier and V677A is its series regulator. The error-feedback circuit (R650 and R651) is connected to the grid of V664. The top end of R650 is connected to the regulated +100-volt output and the lower end of R651 receives a reference voltage from the regulated −150-volt supply. With normal line voltages and loads, the bias voltage at the grid of V664 is about −1.7 volts.

If the load current, output voltage, or the input voltage changes (including ripple), the output of the regulated +100 volt supply starts to change. Any change appears across R650 and R651 and is applied to the grid of V664 as a change in operating bias. Assuming that the output of the regulated +100-volt supply tries to decrease, the reduced voltage at the top of R650 permits the voltage at the junction of R650 and R651 to go more negative than the normal −1.7-volt level. The increase in negative bias on the grid of V664 reduces the plate current of V664. The voltage drop across plate load resistor R663 decreases; the plate voltage of V664 and the grid voltage of V677A go more positive. As the grid of V677A goes more positive, the resistance of V677A is decreased. The voltage across V677A decreases, compensating for most of the drop in output voltage. The regulator circuit can never completely compensate for a change in output voltage because there must be an error input for the circuit to operate from. However, any error in output is reduced by a factor equal to the loop gain of the regulator circuit.

The screen grid of V664 is used as a signal grid for injecting a sample of any ripple or transient voltage present in the unregulated side of the +100-volt supply into the regulator circuit. The regulator circuit thereby becomes a dynamic filter for ripple reduction. The ripple signal applied to the screen of V664 is amplified, inverted, and applied to the grid of V677A. The amplified and inverted ripple at the grid of V677A is of proper amplitude and phase to cancel most of the ripple which would otherwise appear at the plate of V677A.

The +325-volt unregulated supply source differs from the voltage sources for the −150- and +100-volt supplies in that it uses a center-tapped transformer winding and two diode sections (D702) to provide full-wave rectification. A simplified sketch is shown in Fig. 3-2(A). The negative side of the rectifier circuit is connected to ground through D672 and its associated T601 winding. This elevates the negative side of the +325-volt unregulated supply to about +180 V. Approximately 145 V is developed by D702 and the center-tapped winding. This adds to the +180-V supply, forming the +325 V unregulated output.

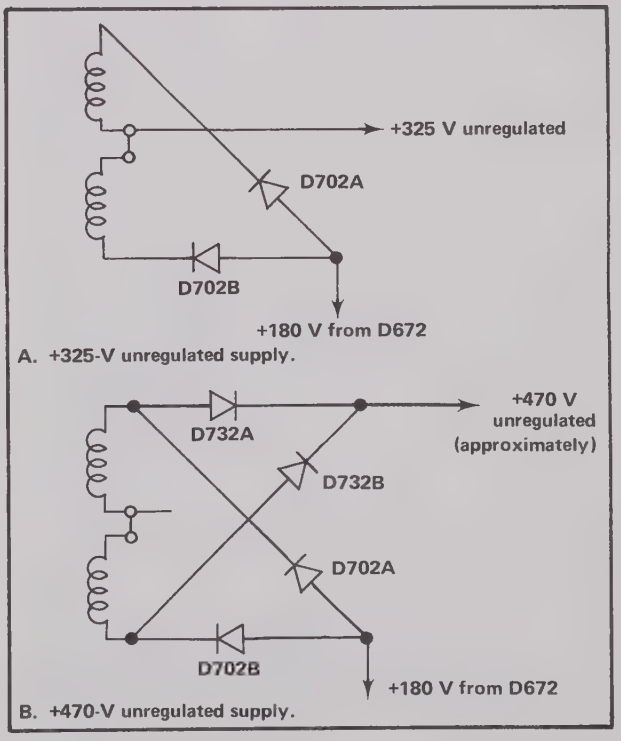


Fig. 3-2. Voltage sources for +325-V unregulated and +470-V unregulated power supplies. Note that D372A and B are not used for the +325-V supply, and that the center-tap of the winding is not used for the +470-V supply.

The +225-volt supply is powered by the unregulated +325-volt supply described in the preceding paragraph. The regulator circuit is similar to the regulator circuit in the

−150-volt supply; the main difference being that instead of using a glow tube as a reference voltage source, the reference voltage is the −150-volt supply. The error signal is picked off the junction of precision resistors R680 and R681. The upper end of R680 is connected to the +225-volt output, and the lower end of R681 is connected to the regulated −150-volt supply. The voltage at the junction between R680 and R681 is approximately −0.1 volt, which is applied through R682 and R683 to the grid of V684B. The cathodes of V684 are long-tailed (coupled through a large resistor) to the −150-volt supply. The grid of V684A is grounded. The error signal is fed from the grid of V684B through the common-cathode circuit to the plate in the A side of the tube. The amplified error-signal is coupled from the V684A plate to the voltage divider in the grid of V694. V694 amplifies and inverts the error signal and applies it (out of phase with respect to the change in the +225-V output) to the grids of series regulators V677B and V737B.

A sample of the unregulated supply ripple is applied to the screen grid of V694, which acts as a control grid for ripple reduction. V694 amplifies the ripple, inverts it, and applies it to the grids of series regulators V677B and V737B. Most of the ripple is thereby absorbed by the tubes.

The +350-volt supply uses the same two windings that were used for the +325-volt unregulated supply. However, the center tap is ignored and the two windings series-aid each other, combining with D702 and D732 to form a bridge rectifier similar to those in the +100-volt and −150-volt supplies. See Fig. 3-2(B). Since each winding develops approximately 145 volts, the two combined develop about 290 volts. With the negative side of the winding referred to +180 volts, the 180 V and the 290 V combine to deliver about +470 volts to the +350 V regulator circuit. The operation of the +350-V regulator circuit is very similar to the operation of the +100-volt regulator.

The +500-volt supply is obtained by adding full wave rectified voltage (from a T601 secondary winding and D762) to the regulated +350-volt supply. The operation of the regulator circuit is similar to that of the +100-volt regulator.

CRT Circuit ◇2

Refer to the CRT Circuit diagram near the back of this book. The CRT circuit includes the CRT, the High-Voltage Power Supply and the controls necessary to focus and orient the display. The CRT is an aluminized, 5-inch, flat-faced, glass device with a helical post-accelerator. It employs electrostatic focus and deflection. The CRT circuit provides connections for applying external modulation to the CRT cathode. The High-Voltage Power Supply is composed of a DC-to-50 kHz power converter, a voltage regulator circuit, and three high-voltage outputs. Front panel controls permit external adjustment of trace rotation (screwdriver adjustment), intensity, focus and astigmatism. Internal controls permit adjustment of the geometry and high-voltage output.

High-Voltage Power Supply. The high-voltage power supply consists of a 50 kHz modified Hartley oscillator (V800) whose coil is the primary of transformer T801. The transformer secondary windings provide three high-voltage outputs. C808 and the primary of T801 form the oscillator resonant tank circuit.

Voltage Regulation. Voltage regulation of the high-voltage outputs is accomplished by controlling the oscillator's output amplitude. The −1700-volt output (CRT cathode supply) is referenced to the +350-volt regulated supply through voltage divider R840-R843, R845-R847. The −1700-volt output is sampled at the R841-R842 junction, and V814B compares the sample against the −150-V supply, applying the resultant voltage to amplifier V814A. This provides a control voltage to the screen grid of oscillator tube V800. If the −1700-volt output changes, the change is detected at the grid of V814B. The screen grid acts as a control grid, determining the amplitude of the 50 kHz oscillations. Any change in the −1700-volt output thus controls the oscillator. R840 controls the high-voltage output by controlling the resistance across which the high voltage sample is taken.

CRT Grid Supply. A winding of T801 and rectifier V822 provide the approximate −1700-volt CRT control-grid supply. The positive side of the supply is referenced to the Cathode Voltage of the Time Base A unblanking circuit and/or Time Base B unblanking circuit, or the +100 V, depending upon the position of the Horizontal Display switch. The negative side of the supply is applied through the INTENSITY control to the CRT grid. Any change in the selected cathode voltage causes a corresponding change to occur at the CRT control grid, causing either blanking, unblanking, or intensification to occur. When the HORIZONTAL DISPLAY switch is at either of the EXT positions, a fixed reference is provided by the +100-V Power Supply, and the grid voltage is controlled solely by the INTENSITY control setting.

A bypass network (consisting of R827, C829 and C830) AC-couples rapid voltage transitions to the CRT. This permits unblanking to occur sufficiently fast to display the leading edges of sweeps. For short-duration unblanking pulses such as those that occur at the fastest sweep rates,

the DC levels on the rectifier and secondary winding are not appreciably affected. Longer unblanking pulses (such as those that occur at the slower sweep rates) charge the stray capacitance in the 1700-volt output through R827. This pulls up on the floating CRT grid circuit and holds the CRT grid at the unblanked potential for the duration of the unblanking pulse.

+8300-V (Accelerating Anode) and −1700-V (Cathode) Outputs. Both the +8300-V and the −1700-V outputs are derived from the same T801 secondary winding, which is referenced to the +100-V Power Supply through a decoupling network. The full secondary voltage of approximately 2900 volts is applied to a voltage tripler consisting of rectifiers V832, V852 and associated capacitors. A tap on the secondary provides electrons for half-wave rectifier V862 in the −1700-volt output. The −1700-volt supply is referenced to the regulated +350-volt supply through a voltage divider network. (The function of the voltage divider is explained under "Voltage Regulation".) The +8300-volt output is connected to the CRT accelerator anode; the −1700-volt output is connected to the CRT cathode via R875 to provide a total accelerating voltage of approximately 10,000 volts.

CRT Circuit Controls and Connectors. To obtain optimum spot size and shape, both the FOCUS (R846) and ASTIGMATISM (R864) controls are adjusted to voltages which provide the proper electronic lens configuration in the region of the second and third anodes of the CRT. Varying the INTENSITY Control (R826) changes the voltage on the CRT grid, which in turn varies the beam current. Internal GEOMETRY control R861 adjusts the isolation shield voltage in the CRT, and is adjusted to minimize "bowing" of the display. The setting of the front-panel TRACE ROTATION control (R778) determines the current which flows through L778. The resultant electromagnetic field determines the degree of parallelism between the horizontal trace and the CRT horizontal graticule lines.

When the instrument is used with a multi-channel vertical plug-in preamplifier that provides dual-trace chopped blanking pulses, the blanking pulses are internally applied to rear-panel CRT CATHODE SELECTOR switch SW858. With the vertical plug-in preamplifier operating in the chopped mode and SW858 set to the CHOPPED BLANKING position, a positive pulse of approximately 20 volts is applied through C858 to the CRT cathode. At normal intensity levels, this pulse is sufficient to cut off the CRT during the time the vertical plug-in is switching from one channel to another.

An input binding post on the rear panel of the instrument provides an AC-coupled input to the cathode to permit intensity modulation to be applied from an external source. The applied AC or transient changes in bias potential affect the intensity of the CRT beam and its resulting trace. The input binding post is normally grounded by a link, which must be disconnected during external blanking.

Vertical Amplifier ◇3

General. Refer to the Vertical Amplifier schematic diagram. The grid and cathode DC voltages for V494A and V494B are determined by the vertical plug-in unit. This determines the operating voltage of Q514 and Q524, the drivers for the Input Amplifier section of the Vertical Amplifier. The DC voltage and accompanying signals at the plates of V514A and V514B are applied through the 186 Ω Delay Line to the bases of the Output Amplifier Drivers, Q594 and Q584. Vertical deflection signals are taken from the plate circuits of V594 and V584.

Q534 drives vertical beam indicators B538 and B539. It is driven by the current through the upper half of the Input Amplifier. Q543 provides vertical trigger signals and a front-panel VERT SIG OUT in response to signal current through the lower half of the Input Amplifier stage.

The gain of the entire Vertical Amplifier circuit is approximately 70, delivering the 7 V/division required by the CRT in response to a 100 mV/division signal from the vertical plug-in unit.

Cathode Follower Stage. The DC voltage and accompanying signals appearing at J11 terminals 1 and 3 control the cathode voltages of V494A and V494B, drawing electrons from ground through R495, R494 and R496. The majority of this current flows through V494A and V494B, and a minute portion of it flows through the DC shift circuit which consists of R499, R500, R501 and R502. R495 (DC BAL) is adjustable, permitting adjustment for individual differences which exist between the transistors used as Q514, Q524, Q584 and Q594. A parasitic suppression circuit (C489, R491, R498) exists in the grid circuit of the Cathode Follower stage. High frequency noise which occurs in either side of the input circuit is coupled through T500 to the other side, making it "common-mode" to the two sides of the amplifier. ("Common-mode" means identical voltage or signal components which appear at the points under consideration.) The common-mode rejection capabilities of the amplifier effectively keep most of the noise from appearing on the CRT.

Input Amplifier Stage. DC levels supplied by the cathode followers control the base voltages of Q514 and Q524. This controls their emitter voltages and determines the amount of electrons which flow from ground through R517. Under balanced input conditions, the electron flow is divided equally between the upper and lower half of the stage, and no current flows through the R519, R520 circuit. The bases of Q513 and Q523 are held at about +175 V by voltage divider R532-R533. This holds the emitter voltages of these transistors at about +174.4 V. The voltage drop caused by the electron flow through R511 and R526 subtracts from this +174.4 V to determine the voltage which is applied (through the Delay Line) to the Output Amplifier stage.

R513 and R523 are in the circuit to provide thermal compensation for Q514 and Q524. C513 and C523 are bypass components for high frequency signals. V514A and V514B act as voltage buffers, reducing the voltage being applied across the transistors. In addition, they "bootstrap" Q514 and Q524 to maintain relatively constant voltages across Q514 and Q524 over a wide range of common-mode input voltages. The "bootstrapping" feaure avoids changes in the signal response of Q514 and Q524 which could otherwise result when shifting between plug-in units. (A relatively wide range of common-mode operating voltage differences exists between the outputs of various plug-in units which can be used with the Type RM545B.)

The bootstrapping occurs as follows: The large value of R501 causes the wiper to feel almost all of any common-mode voltages which occur at the top and bottom of R499 and R500, respectively; this causes a corresponding voltage to be felt at the grids of V514A and V514B any change occurring at the grids causes an equal change at the V514A and V514B cathodes; the change is also felt (through R513 and R523) at the Q514 and Q524 collectors.

Notice that the common-mode voltages which control the voltages at the base and emitter of Q514 and Q524 also control the voltages at the collectors of the transistors. Thus, for common-mode signals, the voltage difference between collector, base and emitter remains essentially constant over a wide range of common-mode input voltages, permitting unchanged transistor operation. It should also be noted that push-pull input signals cause no change at the R502 wiper, since equal but opposite changes occurring simultaneously at the top of R499 and bottom of R500 cause no change in voltage at their common junction. R502 is adjustable to permit thermal balancing of Q514 and Q524. When it is properly set, minimum trace drift will occur in response to DC or low frequency signal inputs.

The gain of the Input Amplifier is a function of the load impedance (R511+R526 in parallel with the 186 Ω impedance of the delay line) divided by the emitter resistance (R515+R516 in parallel with R519+R520 plus the emitter resistances of the transistors themselves) and is equal to approximately 1. R520 and C520 are adjustable, permitting calibration of the gain factor at both low and high frequencies.

C533 (base circuit of Q513 and Q523) provides decoupling to that circuit, while L533 (ferramic bead) suppresses high-frequency oscillations which could otherwise occur.

Vertical Output Amplifier. The input to the vertical output amplifier properly terminates the 186 Ω Delay Line by matching its 186 Ω impedance. C568, L554, and L560 permit accurate adjustment of the termination.

The Output Amplifier is a wideband amplifier stage consisting of Q584, Q594, V584 and V594 and associated components. Its operation can be compared to that of the Input Amplifier circuit which was described previously. Noticeable exceptions are that no "bootstrapping" is used, and the ratio of load impedance to emitter impedance is much larger, resulting in a gain of about 70. High-frequency compensation in this stage is provided by peaking coils L588, L589, L598 and L599 in the plate circuits of V584 and V594. C577, C581, R578 and R580 permit adjustment of the high-frequency response.

Beam-Position Indicators. The operation of Q513 and Q523 must be discussed further before the Trigger-Pickoff circuit can be understood. Since the base and emitter voltages of these transistors are held constant, a fixed amount of current flows through R510, R527 and R509. The E/R requirements of these resistors demands less current than is flowing through V514A and V514B. The rest of the V514A and V514B current flows through Q513 and Q523. When the circuit is balanced, the current through these two transistors is approximately equal. This sets up a bias condition on Q534 which permits it to conduct enough current to place about +280 V at the bottom of R535, which is also the B538-B539 junction. B538 and B539 are kept extinguished, since this balanced condition provides insufficient drive to illuminate either one.

When an unbalanced condition occurs in the amplifier, the currents through Q513 and Q523 become unequal. If Q513 is conducting the greater amount, Q534 turns on

harder, lowering the voltage at the B538-B539 junction. This causes B538 to illuminate, indicating that the trace is above graticule center. Conversely, if Q523 is conducting the greater amount, Q534 conducts less and raises the junction voltage. B539 then illuminates.

R508 provides thermal balance for Q513; L528 and LR529 provide thermal balance for Q523 and also reduce the effect of high-frequency signals on the indicators.

Trigger-Pickoff Circuit. The logic that explains the development of signals to Q534 also pertains to the signals which drive Q543. All signal inputs cause a signal to be felt at the base of Trigger-Pickoff Emitter Follower Q543. The emitter follower configuration provides isolation between the Vertical Amplifier and the actual trigger circuits. L528 and L529, in addition to their functions in the Beam Position Indicator circuit, aid in the development of high-frequency signals for the Trigger-Pickoff circuit.

Time Base A Trigger ◇4◇

Refer to the Time Base A Trigger section of the Block Diagram in the back of the manual. The TRIGGER SLOPE switch can select any one of three signals to drive the Trigger Input Amplifier circuit. In addition, it selects the signal slope (+ or —) which causes triggers to occur. The output of the Amplifier controls the Trigger Multivibrator, which is bi-stable in all except AUTO mode. When the TRIGGERING MODE switch is at AUTO, the Multivibrator is capable of free-running at approximately 50 Hz. Incoming signals of higher frequency override the free-running multivibrator and slave it to their frequency, permitting a stable display to be presented.

Refer to the Time Base A Trigger diagram. The input to the Time Base A Trigger circuit is selected by TRIGGER SLOPE switch SW10A from one of three sources: the trigger-pickoff circuit in the vertical amplifier, the power transformer (line triggering), or from the front panel TRIGGER INPUT connector. TRIGGERING MODE switch SW10B permits further selection of the type of triggering signal: automatic, AC low-frequency reject, AC or DC. Once the type and source of triggering signal has been selected, the slope on which triggering is desired is selected by TRIGGER SLOPE switch SW10A.

After the triggering signal has been selected, it is applied to trigger input amplifier V24. A positive-going signal is required from the plate of V24B in order to generate negative-going trigger signals out of Q45. The TRIGGERING LEVEL control enables the operator to select the point on the incoming signal at which a trigger signal will be generated. To trigger from a positive-going input signal, the grid of the V24A section is connected to the input signal source. The grid of the V24B section is then connected to a DC bias source, which is adjustable through the TRIGGERING LEVEL control. This bias voltage establishes the voltage present at the plate under no-signal conditions.

Voltage at the plate of V24B changes in phase with that at the grid of V24A. Thus, the V24A section acts as a cathode-follower, and the signal voltage developed across the cathode resistor becomes the input signal to the V24B section.

To trigger from a negative-going signal, the grid of the V24A section is connected to the TRIGGERING LEVEL control, and the grid of V24B is connected to the input signal. With this configuration, the voltage changes at the plate of V24B occur 180 degrees out of phase with the input-signal voltage.

In each of the cases outlined above, a positive-going signal is produced at the plate of V24B in response to the selected slope of the input signal.

Q34 is a current-driven amplifier whose emitter is connected to a +100-V decoupled supply. This holds its base at approximately +100.6 V. When the plate of V24B is more than 0.5 V below this value, D29 supplies all of the current for R29, holding D30 cut off. The +100.6 V causes about 0.85 mA to be drawn through R33. R37 has +100 V connected to its right side, and with +100.6 V on its left side, almost no current flows through it. The 0.85 mA flowing through R33 must leave the circuit through R31, setting the potential at the R31-R35 junction at about +102 V. This potential causes about 4.6 mA to flow through R35. The total current (about 5.4 mA) flows through D32, R32 and R34. Q34 conducts about 4.2 mA to supply the remaining current required to satisfy that demanded by R34. The voltage at the Q35 base is thus at about +102.6 V and that at the collector of Q34 is at about +110 V. Q35 is held in conduction, with its emitter and collector voltage interacting to hold Q45 cut off.

Now assume that the voltage at the V24B plate has risen to more than 0.5 V above that at the Q34 base. D29 cuts off and D30 conducts the R29 current, turning Q34 on harder. A small amount of the R29 current flows through the Q34 emitter-base junction. The Q34 collector current increases, lowering its collector voltage, until the voltage at

the R31-R35 junction drops to about +98 V. The current through R31 reverses. The 0.8 mA from R33 plus about 1.2 mA from R33 join to make up the current demanded by R29. Under this condition, the Q35 base voltage drops to about +98.6 V. The Q35 collector voltage rises, and Q45 turns on rapidly. The combination of Q45 emitter voltage and Q35 base voltage turns Q35 off. A fast negative-going signal is developed at the Q45 collector and is sent to the sweep generator circuit.

The preceding description assumed that the V24B plate potential changed enough to cause all or none of the 2 mA of R29 current to flow through D29, resulting in approximately 3 V of change at the base of Q35. In actual operation, less than 1 V at the Q35 base is required to change the state of the multivibrator. D29-D30 current-changes which are much smaller than 2 mA can therefore cause triggers to develop.

When the V24B plate voltage is again driven negative by the signal applied to the V24 grid, current increases through D29 and decreases through D30, decreasing the Q34 conduction. Its rising collector voltage turns Q35 on and Q45 off, resetting the multivibrator in preparation for the next triggering signal.

The D29-D30 limiting action is required to prevent overdriving the multivibrator, so that the trigger circuit may respond properly to a large range of signal voltages and frequencies. R39 (TRIG LEVEL CENTERING) permits adjustment of the V24 plate voltage so that trigger signals can be generated when the grid voltages of V24A and V24B are approximately equal.

The amplitude of the triggering signal necessary to cause operation of the trigger multivibrator is determined by the setting of the TRIGGERING LEVEL control.

A count-down feature is built into the circuit to permit the multivibrator to operate at sub-multiples of incoming high-frequency signals. The inductive component of LR45 causes the beginning of changes in Q35 collector voltage to create a higher voltage at the Q45 base than would otherwise occur because of the resistive voltage divider. About 0.1 μs is required for the inductive effects to decay. When low-frequency input signals are being received, this has little effect except to speed up the switching action of Q45. However, when incoming signal frequencies approach 10 MHz, the inductive "bump" is still present at the base of Q45 when Q24 and Q34 send another triggering signal through. Since the Q45 base voltage controls the Q45 and Q35 emitter voltage while Q45 is conducting, the inductive "bump" biases Q35 off by an amount sufficient to prevent signals at the Q35 base from resetting the multivibrator. The "bump" disappears after about 0.1 μ permitting subsequent triggering signals to reset the multivibrator. D29 and D30 aid this "countdown" action by limiting input signals to a value which is insufficient to override the inductive effect of LR45.

In the AUTO position of the TRIGGERING MODE switch, the trigger multivibrator is converted from bistable to free-running configuration. This is accomplished by disconnecting the +100 V from the junction of D49 and R38, thereby allowing C49 to charge and discharge.

In this mode of operation, the trigger multivibrator will run in the absence of a triggering signal. For example, assume that Q35 is just being driven into cutoff. The voltage at the collector of Q35 rises, carrying with it the base of Q45. As the voltage at the base of Q45 rises, Q45 starts to conduct. The voltage at the collector of Q45 attempts to decrease but must wait until C49 changes its charge. This delayed voltage change is coupled through R37 to the base of Q34. The decreasing voltage at the base of Q34 causes the collector voltage to rise. Q34 is driven into cutoff after a time determined by the time constant of C49 and associated resistances. When Q34 goes into cutoff, it causes Q35 to conduct. The lowered collector voltage of Q35 is coupled through D43 to the base of Q45, thus causing Q45 to cut off. When Q45 cuts off, its collector voltage attempts to rise, but is again delayed by C49. When the collector voltage rises sufficiently, it causes Q34 to conduct enough to lower the Q35 base voltage to the point where Q35 cuts off. Q45 then conducts and another cycle is initiated.

R47 (TRIG SENS) permits adjusting the AUTO repetition rate. D43 and D49 provide fixed voltage drops without appreciable effect upon signals.

Time Base A Generator ◇5◇

Refer to the block diagram in the back of this manual and assume that the HORIZONTAL DISPLAY switch is in the A position. The Time Base A Generator consists of the Sweep Gating Multivibrator, the Disconnect Diodes, the Miller Runup circuit, and the Holdoff circuit. Additional outputs from the circuit are provided through the +Gate Out, the Sawtooth Out, the Unblanking Cathode Followers, and the Multi-Trace Sync Amplifier.

During AUTO or triggered operation, the square wave signal from the Time Base A Trigger circuit is applied to the Sweep Gating Multivibrator, where the negative-going edge causes the multivibrator to change states. A negative gate is thus applied to the disconnect diodes while a positive gate goes to the + GATE OUT cathode follower to be made available at the front panel. A positive gate also goes to the Unblanking Cathode Follower to supply an unblanking signal to the CRT to permit the sweep to be displayed.

When the Disconnect Diodes are turned off, the Miller Runup circuit creates a linear sawtooth voltage which is applied through the HORIZONTAL DISPLAY switch to the Horizontal Amplifier to create a trace across the CRT. When the Miller Runup sawtooth reaches a preset amplitude, its effect through the Holdoff circuit resets the Sweep Gating Multivibrator. The +GATE ends and the unblanking voltage is removed from the CRT. The Disconnect Diodes turn on and the output of the Miller Runup circuit returns to its quiescent value. The RC time of the Holdoff Circuit causes an exponential change of the voltage being applied to the Sweep Gating Multivibrator, preventing the circuit from being triggered until it stabilizes.

At the time the Multivibrator switches states to end the sweep, it sends a pulse out through contacts of the HORIZONTAL DISPLAY switch to the Multi-Trace Sync Amplifier. The Amplifier output is then applied to any multichannel vertical plug-in unit which may be inserted into the oscilloscope. There it causes 'alternate' vertical channel switching to occur when selected at the plug-in unit.

Another output from the Multi-Trace Sync Amplifier goes to the DUAL TRACE CHOPPED BLANKING switch (rear panel of the oscilloscope) to blank out transients which would otherwise appear during "chopped" operation of multi-channel vertical units.

When the HORIZONTAL DISPLAY switch is in the 'B' INTENSIFIED BY 'A', 'A' DLY'D BY 'B', or 'A' SINGLE SWEEP position, circuit operation is essentially the same, but the Lockout Multivibrator circuit prevents a sweep from being initiated until after the circuit has been reset by a delayed trigger ('B' INTENSIFIED BY 'A' mode and 'A' DLY'D BY 'B' mode) or by depressing the RESET button ('A' SINGLE SWEEP mode).

Operation of the Time Base A Generator when the HORIZONTAL DISPLAY switch is in the B or EXT position is the same as described for 'A' sweep operation. However, only the +Gate A and SAWTOOTH A outputs are used in those modes.

'A' Sweep Operation.. Refer to the Time Base A Generator schematic. The ability of the circuit to respond to incoming trigger signals is dependent upon the setting of the STABILITY control, R110. If it is set close to ground, the circuit cannot respond to triggers and no sweeps will be generated. If it is set close to −150 V, V135A will cut off and initiate a new sweep immediately after the preceding sweep has ended, independent of incoming signals. The PRESET switch (connected to the STABILITY control) permits rapid selection of a biasing voltage which will permit triggered operation under most conditions. The "preset" voltage is selected whenever the STABILITY control is fully counterclockwise.

The STABILITY control effect is felt (through cathode follower V125) at the grid of V135A. Under quiescent conditions (when the STABILITY control is set for triggered operation) V135A is conducting and its grid voltage is near enough to cutoff potential for incoming triggers to control it. V145 is held cut off by the V135A plate potential which is felt through cathode follower V135B. This voltage also holds V193A cut off and holds V183B in a low-conduction state.

With V145 cut off, the R147-R148 voltage divider attempts to raise the V145 plate potential to about +2 V. However, the voltage is held to about −3 V by electrons from V152A and V152B. V152A conducts electrons which are obtained from the −150 V power supply through R173, R174, R176 and R178. V152B conducts the small amount of current which is obtainable through R160. The voltage on the grid of V161 is thus being controlled by the voltage at the plate of V152B, which is controlled by the voltage at the cathode of V173.

Note that the V161 plate voltage controls the grid voltage of V173. (B167 is a constant-voltage device and is included to step down the voltage applied to the V173 grid, without detracting from sweep signals.) The large resistance in the V173 cathode circuit causes the cathode to follow the grid voltage. Since this cathode voltage effectively controls the V161 grid voltage (through V152) the closed loop which exists causes the circuit to stabilize at fixed values whenever V152 is conducting. Approximately −4.5 V appears at the V173 cathode and −3 V appears at the V161 grid.

The negative voltage felt at the wiper of R176 controls the grid voltage of V183A. The large resistance in the cathode circuit causes the cathode to follow, and places the V133B grid voltage at a potential which, when compared to the value selected by the STABILITY control for triggered operation, holds V133B cut off. With 'A' sweep selected, the plate circuit of V133A is floating so V133A has no effect upon sweep generator operation.

When a negative-going signal is applied to C131, its differentiated result is felt across R131 and applied to the V135A grid. V135A decreases conduction, causing its plate voltage to rise. The V135B cathode voltage follows, pulling up on the grids of V183B, V193A and V145. The V145 cathode follows its grid, and increases the drop across R144 to the point where V135A is biased into cutoff.

The positive voltage on the V135B cathode is coupled out through cathode follower V183B to unblank the CRT, and through cathode follower V193A to provide the +GATE A at the front panel.

When V145 turns on, its plate voltage drops suddenly, turning V152A and V152B off. The R160 current starts to build up on the lower plate of C160, causing the V161 grid to go negative. The V161 plate voltage is driven positive, causing the V173 cathode voltage to follow. This raises the voltage on the top of C160 by an amount almost equal to the negative charge accumulating on its bottom. The net effect is that only a small negative-going change is felt on the bottom of C160 with respect to ground.

The V161 stage gain is approximately 500. A +150-V sawtooth therefore develops on the cathode of V173 and at the top of C160 in response to a –0.3 V change on the V161 grid. Since only 0.3 V change occurs on the top of R160, its E/R ratio remains almost constant during sweep time, causing C160 to charge at a linear rate. The result is a linear sawtooth voltage out of the circuit.

A portion of the sawtooth voltage is felt at the R176 wiper, causing the V183A grid and cathode voltage to rise. When the sawtooth becomes sufficiently large, V133B starts to conduct. When the sweep voltage rises sufficiently to cause approximately 10.5 divisions of trace deflection, the V133B cathode causes V135A to conduct. Its plate voltage drops, causing a decrease in V133B cathode voltage. V183B then sends a blanking voltage to the CRT and V193A returns the +GATE A voltage to its quiescent value.

With V135A pulling up on the voltage at the top of R144 and the V135B cathode voltage pulling down on the V145 grid voltage, V145 rapidly turns off. Its plate voltage rises, turning V152B on. The V161 grid voltage moves in a positive direction, rapidly decreasing the V161 plate voltage and the V173 cathode voltage until V152A conducts. The Miller Runup circuit then stabilizes at its quiescent values.

The voltage at the R176 wiper decreases in step with the V173 cathode voltage, pulling down on the grid of V183A. The cathode of V183A cannot follow the rapid voltage transition on the grid because of the RC time of C180 and R181. V183A goes into cutoff and V133B is held in conduction for a period of time determined by this RC "hold-off" circuit. While V133B conducts, it holds the V135A grid voltage sufficiently positive to prevent incoming triggers from again triggering the multivibrator. When enough time has elapsed to permit the Miller Runup circuit to stabilize, the C180 voltage becomes negative enough to cut V133B off, permitting the STABILITY control to determine the V135A grid voltage. The V135A-V145 multivibrator can then be triggered into another cycle of operation.

The sweep voltage (cathode of V173) is applied through R196 and C196 to the grid of V193B. The large value of R199 causes the V193B cathode voltage to follow the grid, making the sweep voltage available at the SAWTOOTH A output connector without appreciably loading the sweep generator.

When a multi-trace vertical plug-in unit (operating in "alternate" mode) is used with the oscilloscope, the plug-in unit supplies a negative voltage to the V154A cathode and a positive voltage to its plate. V154A is biased at or near cutoff by the R151-R152 voltage divider. When V145 cuts off, the inductive component of LR149 causes a positive spike to develop at the V145 screen grid. The spike is felt at the grid of V154A. V154 conducts and develops a positive spike in its cathode circuit, sending the spike to the plug-in unit to cause channel switching to occur.

When "chopped" mode is selected at the plug-in unit, the voltages applied to V154A by the plug-in unit are modified and V154A is disabled. However, the plug-in unit applies a negative pulse to C157 each time the plug-in switches from one channel to another. The negative pulse applied to the V154B grid creates a positive pulse in the V154B plate circuit. This positive pulse is then applied to the CRT cathode to blank the electron beam during channel switching time. This prevents the chopping transients from appearing on the CRT.

When the HORIZONTAL DISPLAY switch is at 'B' INTENSIFIED BY 'A', 'A' DLY'D BY 'B' or at 'A' SINGLE SWEEP position, circuit operation is identical except that V133A and V114 are put into operation. When any of the three specified positions are selected, +100 V is applied to the plate of V133A. V133A and V125 then form a bistable multivibrator, with their cathodes connected to the V133B cathode.

Assume that a sweep has just been completed and that retrace is occurring. C180 charges negative during holdoff time, lowering the V133B grid and cathode potential. The bias on V125 and V133A is such that V133A is the first to conduct as the V133B current decreases. V133A causes sufficient current to flow through R130 to hold V125 cut off. This voltage is also high enough so that incoming triggers cannot switch the V135A-V145 multivibrator to start a new sweep.

When a positive trigger is received at the grid of V114, it develops a negative pulse at its plate. The negative pulse causes V133A to decrease conduction. This lowers the V133A cathode voltage. Since the V133A and V125 cathode voltages are common, V125 goes into conduction and its plate voltage decreases. The lowered V125 plate voltage is coupled to the V133A grid to hold that tube section cut off. The decreased voltage across R130 places the V135A grid near cutoff. The circuit has been "reset" and is ready to create another sweep.

V114 receives its triggers from the Delay Pickoff circuit during 'B' INTENSIFIED BY 'A' and 'A' DLY'D BY 'B' modes. During 'A' SINGLE SWEEP mode the triggers are obtained by depressing the RESET button. This causes a 150 V positive signal to be coupled through R102 and C102 when C103 loses its −150 V potential.

Miscellaneous Circuit Components. The capacitors in the circuit (other than C103, C160 and C180) are in four general categories: C134, C141, C190, C150, C105 and C123 improve switching action; C165, C167, and C196 improve sawtooth linearity in their respective areas; C131, C151, C157 and C102 are coupling capacitors; C109, C116, C129, C138, C187 and C193 are decoupling capacitors.

D131 shunts positive-going inputs, preventing them from interfering with the Sweep Gating Multivibrator action. D133 limits V135A plate voltage to +100 V during the time that V135A is cut off. B171 is normally de-energized and provides voltage protection for the V173 grid-to-cathode circuit.

R154 and D152 protect against timing current leakage during sweep time, and operate as follows: When V152B is cut off, cathode-to-plate current is effectively stopped. However, the filament voltage is alternately + and − about 9 V with respect to the cathode. If the cathode is permitted to "float", its electron leakage to the filament will pull it positive enough to forward bias D152 and affect sweep timing. R154 provides a source of electrons for the cathode-to-filament leakage, referencing the cathode to a voltage sufficiently negative to keep D172 cut off.

Time Base B Trigger ◇7◇

Refer to the Time Base B Trigger Schematic. The Time Base B Trigger circuit differs from the Time Base A Trigger circuit in its manner of limiting signals which are applied to the trigger multivibrator and also differs in the AUTO multivibrator configuration. These differences are explained here.

D78 and 79 limit the amount of signal current that can be exchanged betwen V74A and V74B to about 2 mA, since this is all that is permitted by the approximately 150 V dropped across R78, and the diodes prevent electrons from flowing from one cathode resistor to the other half of the tube. With only 2 mA of signal current available, the signal voltage drop across R75 is limited to about 5 V. C81, D81 and D82 limit the amplitude of high-frequency signals to about 1.4 V peak to peak, permitting LR84 to control high-frequency count-down in a manner similar to that explained for LR45 in the Time Base A trigger circuit.

The multivibrator consists of Q85, Q95 and associated circuitry. In DC and AC modes, it is driven by signals from V74B. In AUTO mode, the +100 V is removed from the R93-R95 junction, permitting the Q95 collector current to affect the voltage across R92 and C90. Assume that Q95 has just cut off and Q85 is conducting. The voltage at the R92-R93 junction attempts to rise but is delayed by C90. This same voltage influences the Q95 base voltage. When it rises sufficiently, Q95 turns on. The emitter voltage rises and turns Q85 off. The R92-R93 junction voltage now decreases at a rate determined by C90 and the associated resistances until it becomes low enough to cut Q95 off again, permitting Q85 to turn on. The cycle repeats itself at approximately 50 Hz.

Time Base B Generator ◇8◇

Refer to the Time Base B Generator schematic. The Time Base B Generator functions in essentially the same manner as the 'A' Generator. Obvious exceptions are that the 'B' Generator does not have a lockout circuit, a multi-trace sync circuit, or a front-panel sawtooth output circuit.

Delay Pickoff ◇10◇

Refer to the Block Diagram near the back of this manual. Delayed triggers can be applied to the Time Base A Generator in the 'B' INTENSIFIED BY 'A' and 'A' DLY'D BY 'B' positions of the HORIZONTAL DISPLAY switch. The trigger pulses are applied to the sweep generator from Delayed Trigger Amplifier V114, which acts as a coupling cathode follower to apply delayed triggers to the Lockout Multivibrator. Delayed trigger pulses are applied to the grid of V114 from the cathode of V428B. These pulses are shaped and amplified in the Delay Pickoff circuit composed of V414, V424, V445 and V428.

Refer to the DELAY Pickoff schematic. V414 and V424 are combined to form a difference amplifier which picks off a sample of the sawtooth output from sweep generator A or B and converts it into a positive step pulse. Before the pickoff time, V414 is cut off and V424 is conducting. Since the cathodes of V414 and V424 are tied together, V424 determines the common-cathode voltage.

The common-cathode voltage is adjustable by means of DELAY-TIME MULTIPLIER 1-10 (R433), a 10 turn helical potentiometer. V428A is a constant-current triode supplying cathode current to the difference amplifiers from the −150-volt supply. This arrangement permits the cathode of V424 to follow its grid over a wide range with very little variation in cathode current.

Plate current through R424 and L424 remains very nearly constant while V414 is cut off, regardless of the grid voltage set by DELAY-TIME MULTIPLIER R433. This is important since the plate voltage of V424 holds the grid voltage of shaper stage V445A near the triggering points.

The positive-going delaying sweep sawtooth raises the grid of V414 toward its cathode voltage. When the V414 grid voltage approaches the cathode voltage set by the DELAY-TIME MULTIPLIER control, V414 starts to conduct, decreasing the current through V424. As the incoming sawtooth continues to rise, the V424 current progressively decreases until V424 is finally cut off. The speed at which the action takes place is a function of the sweep speed of the incoming signal.

While the V424 current is decreasing, its plate voltage is rising. When it rises through the voltage required to turn V445A on, the Delayed Trigger Multivibrator changes state, producing a fast-positive-going pulse at the V445B plate. The positive-going pulse is differentiated through C454 and transmitted to the succeeding circuits through cathode follower V428B.

The DELAY START and DELAY STOP controls adjust the upper and lower grid voltage limits of V424 as set by the DELAY-TIME MULTIPLIER, so that delay can be read accurately from the DELAY-TIME MULTIPLIER dial.

Horizontal Amplifier ◇11◇

Refer to Fig. 3-3. The Horizontal Amplifier receives its control signal from one of three sources - a sawtooth sweep voltage from the Time Base 'B' Generator, a sawtooth sweep voltage from the Time Base 'A' Generator, or an external horizontal signal from the External Horizontal Amplifier. The selected signal is applied to a voltage divider which has an approximately 3:2 ratio. The attenuated signal is applied to Input Cathode Follower V343A, where it is super-imposed on a quiescent positioning control voltage selected by the Horizontal Position control. The cathode follower output is applied to contacts of a 5X MAGNIFIER switch which, when ON, couples an unmodified signal to V343B. When the 5X MAGNIFIER switch is OFF, the signal is attenuated by a factor of 5. The NORM/MAG REGIS control permits the circuit to be adjusted so that the two divisions of unmagnified sweep which straddle the vertical centerline appear as a 10 division sweep when the 5X MAGNIFIER is turned ON.

The Driver Cathode Follower, Paraphase Amplifier, Output Cathode Follower, and the Current Boost Amplifier combine to form a feed-back amplifier which provides a push-pull output. The push-pull output is approximately 3 times as large as the signal delivered by Input Cathode Follower V343A, giving the entire Horizontal Amplifier circuit a gain of approximately 2 with the 5X MAGNIFIER OFF.

Refer to the Horizontal Amplifier Schematic. The sawtooth waveform from the selected time-base generator is coupled to the input cathode follower through the R330-C330 network. Approximately 2/3 of the signal is developed across the HORIZONTAL POSITION and VERNIER network. C330 permits adjustment of the circuit capacity so that fast sweep rates receive the same attenuation as the slow rates.

With the 5X MAGNIFIER switch ON, the signal is applied directly from the cathode of V343A through R351 to the grid of V343B. The signal is developed in the cathode circuit and applied to the grid of V364A. When the voltage at the V364A grid is approximately equal to that at the grid of V384A, equal current flows through the two tubes, placing the left side of R373 at the same potential as the left side of R376. No current flows through R375 under these conditions. When the voltage at the V364A grid changes, its cathode voltage follows, causing a current change through R373. In addition, the unbalance of voltage also causes current to flow through R375 in proportion to the amount of resistance to which it is set. If the V364A grid signal is positive, current through V364A increases, and since some of it is obtained through R375 and R376, current through V384A must decrease. Paraphase amplification thus results and opposite polarity signals are developed across load resistors R364 and R384. R364 is slightly smaller than R384 because V364A is the driven tube and receives a slightly larger current change than V384A in response to a given signal.

Since the amount of current a signal can deliver to the load resistors is partially dependent upon the value of R375, the circuit gain can be set to obtain calibrated deflection factors by adjusting R375. The paraphase signals are developed in the cathode circuits of Output Cathode Followers V364B and V384B, and applied to the CRT deflection plates. C364 and C384 shunt the cathode followers to supply additional current for fast sweep rates. Additional current is also supplied by V398 during fast sweep rates by applying a signal from the cathode of V384 through C390 to the V398 control grid.

The voltage at the cathode of V364B is fed back through R355 and C355 to cause the amplifier to drive until sufficient feedback current is supplied to stabilize the circuit. This makes the gain of the amplifier circuit dependent upon a ratio between the feedback RC network (R355-C355) and the network at the input of the feedback amplifier (R345). Appreciable changes in the tube characteristics can therefore occur and cause only a minimum effect on circuit gain.

When the 5X MAGNIFIER switch is OFF, C348, R348 and R349 are inserted in the signal path, reducing the gain of the feed-back amplifier by a factor of 5.

Beam Position Indicators. The beam position indicators (B397 and B398) indicate the relative horizontal position

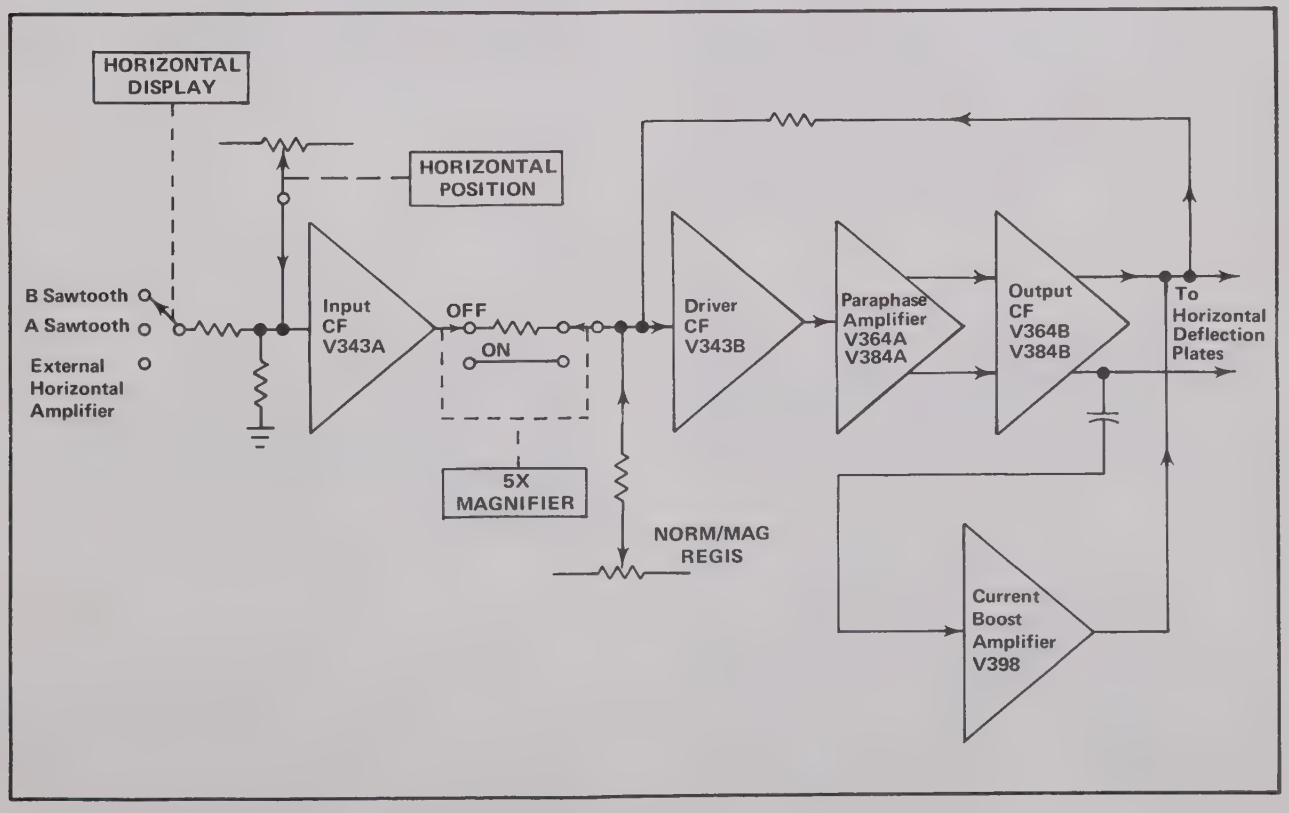


Fig. 3-3. Horizontal Amplifier block diagram.

of the spot or center of the trace with respect to the center of the graticule. When the spot or trace is approximately centered horizontally, the potential across the neon lamps is insufficient to light either one. When the beam is positioned left or right on the CRT, the voltages across the neon lamps change. The voltage across one lamp increases, causing it to light, while the voltage across the other lamp decreases, and it remains extinguished. The lamp that lights indicates the beam's direction from center.

CRT Protection Circuit (SN8590 and above). A CRT protection circuit at the input of the Horizontal Amplifier keeps the CRT beam deflected off-screen during the initial application of power supply voltages. This minimizes the possibility of phosphor burns occurring as a result of high-intensity beam striking the phosphor during turn-on.

When the thermal time-delay relay cuts out, K601 energizes and +225 volts is applied to the circuit. The sudden application of positive voltage causes current flow through R306 and R307. This biases Q307 into saturation, causing the Q307 collector voltage to instantaneously decrease to approximately +0.3 volts. D307 conducts and clamps the grid of V343A at approximately +1 volt. The CRT beam is deflected off-screen by the resultant amplifier action.

As the charge on C307 increases, current through R306 decreases until Q307 becomes biased to cutoff, allowing the collector to go toward +225 volts. D307 becomes back-biased and removes the Q307 influence from the grid of V343A. After this turn-on action occurs, D307 remains back-biased, permitting the voltage at the V343A grid to function normally.

External Horizontal Amplifier

Refer to the External Horizontal Amplifier schematic. When HORIZONTAL DISPLAY switch SW301 is in either the EXT X1 or X10 position an external signal can be fed through the HORIZ INPUT connector to an amplifier whose output is fed to the Horizontal Amplifier.

External signals are applied to the grid of V314A either directly or through the X10 attenuator. The capacitive portion of the X10 attenuator is adjustable to permit compensating for slight differences between inter-electrode capacitance of different tubes used as V314. This assures equal attenuation for both low- and high-frequency signals.

The signal applied to the grid of V314A is then cathode-coupled to V314B. The amplifier gain can be selected by adjusting the VARIABLE 10-1 potentiometer (R314), which determines the amount of cathode coupling. EXT HORIZ DC BAL R317 permits adjusting the cathode of V314B to the same voltage as that of V314A under no-signal conditions. When R317 is properly set, no change of V314B plate voltage will be noticed (under no-signal conditions) when R314 is rotated. The output from V314B is connected to input cathode follower V343A in the Horizontal Amplifier when the HORIZONTAL DISPLAY switch is in either of the EXT positions.

Amplitude Calibrator

Refer to the Calibrator schematic. The Amplitude Calibrator is a square-wave generator with an approximate 1 kHz output available at the front-panel CAL OUT connector. The Amplitude Calibrator consists of multivibrator V875-V885A, cathode follower V885B, and associated circuitry.

When the multivibrator changes states, it switches V885B on and off. When V875 conducts, its lowered plate voltage drives the V885B grid well below cutoff and the V885B cathode rests at ground potential. When V875 cuts off, its plate voltage places the V885B grid slightly below +100 V. When R879 is properly adjusted, the V885B cathode voltage is accurately set to +100 V while V885B is conducting.

Cathode follower V885B has a precision voltage divider for its cathode resistor. Eighteen output voltages from 0.2 mVOLTS to 100 VOLTS are available through this divider, which consists of tapped divider R885 through R893 and 1000:1 divider R896-R897. C885, connected between the cathode of V885B and ground, corrects the output waveform for overshoot.

The source impedance of the CAL OUT signal is 200 Ω at the 0.5 V position. The Amplitude Calibrator therefore provides a 0.1 volt output when the AMPLITUDE CALIBRATOR switch is set to 0.5 volt and a 50 Ω load is connected to the CAL OUT connector.

SECTION 4
MAINTENANCE

Change information, if any, affecting this section will be found at the rear of the manual.

PREVENTIVE MAINTENANCE

Access to Interior

For access to the interior of the oscilloscope, unscrew the four slotted lock-knobs at the front panel. Then slide the chassis out on its tracks, and tilt it as required for most convenient access.

Recalibration

To insure accurate measurements, check the calibration of the instrument after each 500 hours of operation or every six months if used intermittently. The Calibration procedure can also be helpful in localizing certain troubles in the instrument. In some cases minor troubles which are not apparent during normal use may be revealed and/or corrected by recalibration. Calibration instructions are given in Section 5.

VISUAL INSPECTION

The oscilloscope should be inspected occasionally for such defects as broken connections, broken or damaged ceramic strips, improperly seated tubes or transistors, and heat-damaged parts.

The remedy for most visible defects is obvious; however, particular care must be taken if heat-damaged parts are located. Overheating is usually only a symptom of trouble. For this reason, it is essential to determine the actual cause of overheating before the heat-damaged parts are replaced; otherwise, the damage may be repeated.

Cleaning

The oscilloscope should be cleaned as often as operating conditions require. Accumulation of dirt in the instrument can cause overheating and component breakdown. Dirt on components prevents efficient heat dissipation. It also provides a conduction path for electricity. Dirt in the air filter restricts the flow of cooling air and results in excessive operating temperature.

Air Filter. The air filter should be visually checked every few weeks and cleaned if dirty. More frequent inspections and cleaning are required under severe operating conditions. To clean the filter, wash it out in the same manner as a plastic sponge. Rinse the filter thoroughly and let it dry. Coat the dry filter with fresh "Filter Kote" (Tektronix Part No. 006-0580-00 or "Handi-Koter" (available locally through most air conditioner suppliers). Let the filter dry thoroughly before re-installing.

Exterior. Loose dust accumulating on the outside of the instrument can be removed with a cloth or small brush. The brush is particularly useful for dislodging dust on and around the front-panel controls. Stubborn dirt can be removed with a soft cloth dampened in a mild solution of water and detergent. Abrasive cleaners should not be used.

Clean the face of the CRT with a soft, lint-free cloth dampened with denatured alcohol.

CAUTION

Avoid the use of chemicals which might damage the plastics used in this instrument, particularly the lucite plastic CRT faceplate. Avoid chemicals such as benzene, toluene, xylene, acetone and similar solvents.

Interior. Although air entering the oscilloscope is filtered, some dust may penetrate into the interior of the instrument. Clean the interior by first vacuuming all accessible areas; then blow away the remaining dust with dry, low-pressure air. Avoid the use of high-velocity air. It might damage some of the components. Remove remaining dirt with a soft brush or a cloth dampened with a mild detergent and water solution. A cotton-tipped applicator is useful for cleaning in narrow spaces or for cleaning ceramic terminal strips.

WARNING

Use an eye-shield when cleaning with pressurized air.

The high-voltage circuits (including parts located under the high-voltage shield) should receive special attention. Excessive dust and dirt in these areas may cause high-voltage arcing and result in improper instrument operation.

Lubrication

The fan motor bearings should be lubricated every three or four months with a few drops of light machine oil (see Fig. 4-1). Failure to lubricate the fan bearings periodically may cause the fan to slow down and eventually fail.

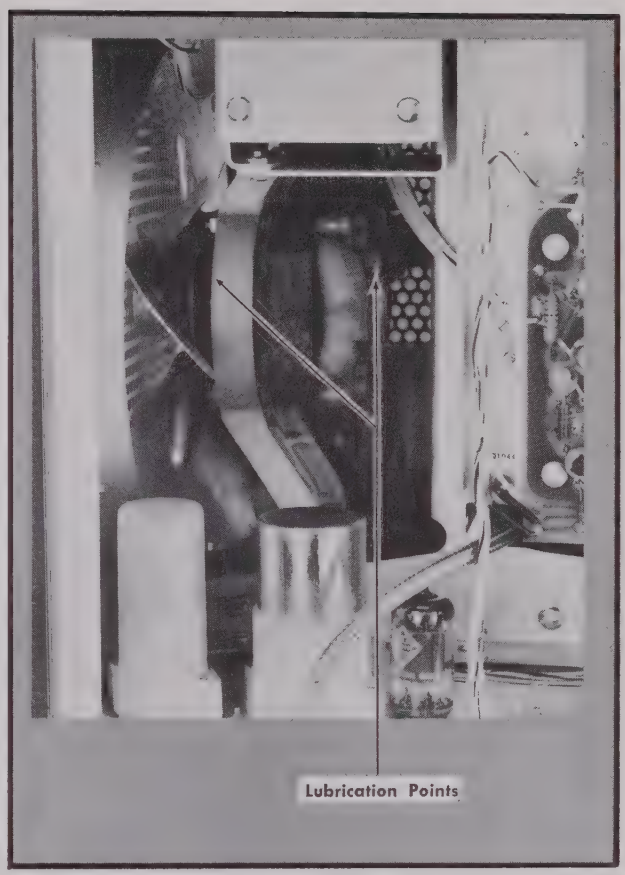


Fig. 4-1. Fan motor lubrication points.

CORRECTIVE MAINTENANCE

Soldering

Special silver-bearing solder is used to establish a bond to the ceramic terminal strips in Tektronix instruments. This bond can be broken by repeated soldering (especially if ordinary tin-lead solder is used) or by excessive heating. Solder containing about 3% silver is recommended. A small supply of this solder is provided on a spool mounted inside the oscilloscope. Additional silver-bearing solder can usually be purchased locally; it may also be purchased through the Tektronix Field Engineer or Field Office—specify Tektronix Part No. 251-0514-00.

The following procedure is recommended when soldering to ceramic terminal strips:

1. Use a wedge-shaped soldering-iron tip about 1/8-inch wide. This allows heat to be applied directly to the solder in the terminal strip, thereby reducing the amount of heat required.

2. Maintain a clean, properly tinned tip.

3. Use a hot iron for a short time. A 50- to 75-watt iron having good heat transfer and storage characteristics is adequate.

4. Avoid putting pressure on the strip. Excess pressure may crack or chip the strip.

5. Apply only enough heat to make the solder flow freely.

6. Do not attempt to fill the notch on the strip with solder; instead apply only enough solder to cover the wires adequately and establish a solid solder joint. Overfilling the notches may result in cracked terminal strips. If the wire end extends beyond the solder joint, clip the excess as close to the joint as possible. Remove all wire clippings from the chassis.

Ceramic Terminal Strips

Fig. 4-2 shows an assembled ceramic terminal strip. Replacement strips with studs attached are supplied under one part number; the spacers are supplied under a separate part number. However, the old spacers may be reused if not damaged.

Usually a strip can be pried out of the chassis or pulled out with a pair of pliers. If desired, a hammer and punch

may be used to drive out the studs from the opposite side of the chassis.

When the damaged strip has been removed, place the new or used (but undamaged) spacers in the chassis holes. Then, carefully force the studs of the new strip into the spacers until they are completely seated. If necessary, use a soft-faced mallet and tap lightly, directly over the stud area of the strip.

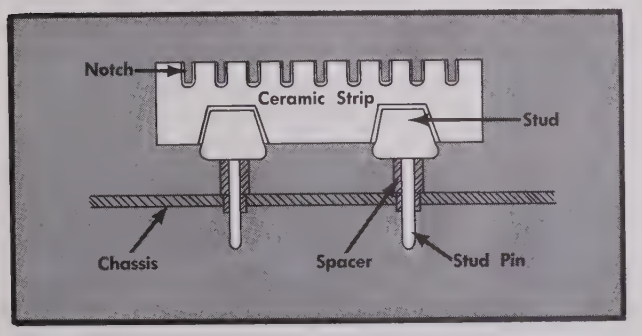


Fig. 4-2. Ceramic strip assembly.

Component Replacement

Certain parts in the instrument are easiest to replace by following a definite procedure. The procedures for replacing these parts are outlined in the following paragraphs.

Many electrical components are mounted in a particular manner to reduce or control stray capacitance or inductance. Duplicate the original location and mounting when replacing components. When selecting replacement parts, remember that the physical nature of a component can affect its performance at high frequencies. After repair, check the instrument calibration.

NOTE

Turn off the instrument power before replacing transistors or other components.

Standard Parts

Many of the components in this instrument are standard electronic parts that can be purchased locally. However, all parts in the instrument can be obtained through the Tektronix Field Engineer or Field Office. Before purchasing or ordering parts, check the parts list in Section 6 to determine the value, tolerance, and rating required.

Special Parts

Some of the parts in the instrument are manufactured or selected by Tektronix to meet specific requirements, or are manufactured to Tektronix specifications. These parts and most mechanical parts should be ordered through the Tektronix Field Engineer or Field Office. See "Parts Ordering Information" and "Special Notes and Symbols" in Section 6.

Tubes and Transistors

Tube-tester checks are not recommended. Testers may indicate a tube to be defective when it is operating satisfactorily in a circuit, or may fail to indicate tube defects which affect the performance of the circuit. It is recommended that tubes be checked by substitution. Transistors can be checked either by a reliable tester or by the substitution method. If the tube or transistor is good, return it to its socket. Unnecessary replacement of tubes or transistors is not only expensive but may also result in needless recalibration of the instrument.

Wafer Switches

Individual wafers are normally not replaced in the switch assemblies. Replacement switches may be ordered from Tektronix either wired or unwired; see the parts list for the part numbers.

When soldering a switch assembly, do not let the solder flow around and beyond the terminal rivet since this may destroy the spring tension of the contact.

Cathode-Ray Tube

To remove and replace the cathode-ray tube, use the following procedure:

WARNING

A mis-handled cathode-ray tube (CRT) may implode and scatter glass at high velocity. Wear an eye-shield and use adequate care when handling the CRT. Prevent the CRT from striking or being struck by other objects. Use moderate pressure when tightening mounting clamps. Place unmounted CRTs in their storage carton. In the absence of a storage carton, gently set the CRT face down on a clean, soft surface. Before attempting to service an installed CRT or its high-voltage supply, discharge the associated high-voltage potential.

1. Disconnect the line-supply voltage from the oscilloscope.

2. At the left-front of the CRT shield, insert a nonconducting plastic rod between the terminal end of the high-voltage lead and the black composition insulating pad which is attached to the CRT shield. Pry out the lead until the cap separates from the pad. Remain clear of the contact spring contained in the cap.

3. Using the plastic rod, maneuver the high-voltage lead until the contact-spring makes contact with chassis ground, discharging the high-voltage power supply.

4. Connect the grounding lead of a shorting bar to oscilloscope chassis ground. Touch the other end of the bar to the CRT high voltage anode, discharging any stored charge. Then remove the shorting bar.

5. Remove CRT bezel nuts, bezel and plastic light filter or CRT protector plate. See Fig. 4-3.

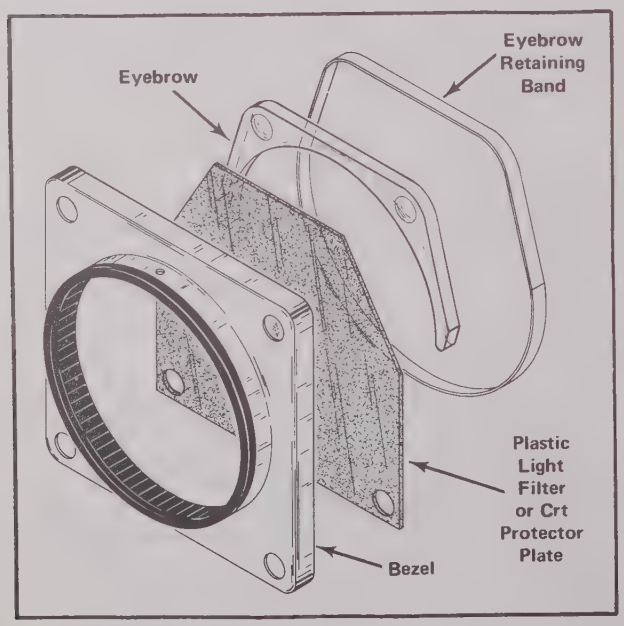


Fig.4-3 CRT BEZEL and eyebrow arrangement.Early models used a Retaining Spring instead of a Retaining Band.

6. Remove plastic eyebrow and retaining band from the top of the CRT. See Fig. 4-3. (A spring is used instead of a band in some lower-serial number instruments.)

7. Disconnect the five leads from the CRT neck. Do not bend the pins. Grip the outer end of the connectors with needle-nose pliers and pull straight away from the glass surface.

8. Using a phillips screwdriver, loosen the CRT base clamp screw. See Fig. 4-4. After loosening the screw about 1/8 inch, push on the screw head to release the upper part of the clamp from the CRT neck.

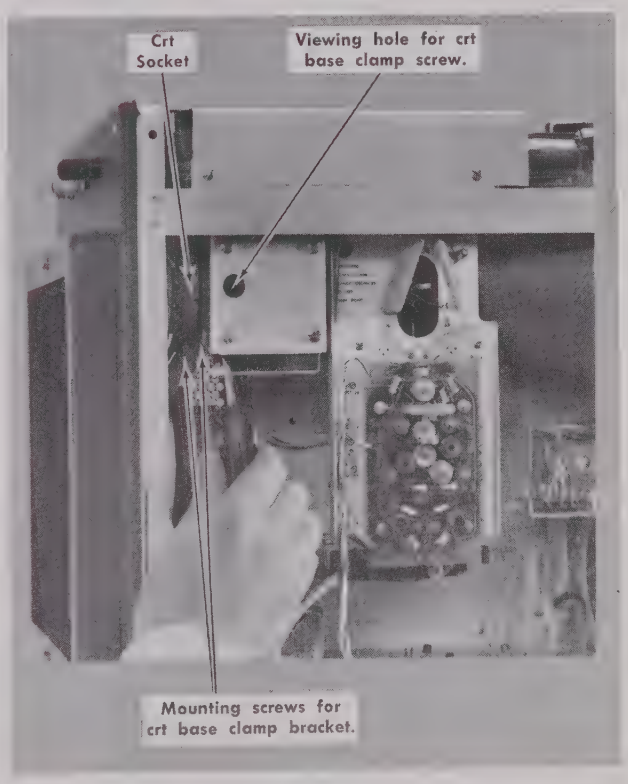


Fig.4-4. Loosening the CRT base clamp.

9. With a chisel-tipped plastic or wooden dowel, carefully work the CRT socket loose from the CRT base.

10. Grasp the face of the CRT with the right hand. Push the CRT carefully toward the front of the oscilloscope with the left hand. Be careful not to bend the neck pins. Remove the CRT through the front of the oscilloscope.

11. Before re-installing the CRT, dust talcum powder on the CRT base. This prevents the base of the CRT from sticking to the neoprene bushing inside the base clamp.

12. Carefully insert the new tube into the shield and the tube base clamp. Keep the anode button in line with the anode connector hole so that the button is aligned with the hole when the CRT is fully inserted.

13. Reconnect the CRT socket to the tube base.

14. Turn the CRT so that the horizontal graticule lines are parallel wih the top of the front panel.

NOTE

If the CRT face is not parallel with the front of the oscilloscope, use a 7/64-inch hexagonal wrench to loosen the two socket-head mounting screws that fasten the base clamp to the mounting bracket (see Fig. 4-4). Move the base clamp and CRT radially to bring the face of the CRT parallel to the front panel of the instrument. Then re-tighten the mounting screws.

15. Install eyebrow and eyebrow retainer band. Position the CRT so that the CRT faceplate and eyebrow are flush.

16. Tighten the base clamp, using moderate torque.

17. Reconnect the anode and neck-pin leads (observe color code).

18. Turn the oscilloscope on and obtain a free-running sweep on the CRT.

19. Check the trace alignment with the graticule lines. If the trace is not parallel with the graticule lines, adjust the TRACE ROTATION control to realign the trace.

20. Remove all smudges and dirt from the CRT face with a soft lint-free cloth dampened with denatured alcohol.

21. Replace light filter (or CRT protector plate), CRT bezel, and bezel nuts.

TROUBLESHOOTING AIDS

Diagrams

Diagrams for each circuit in this instrument are located in Section 6. In addition, a block diagram provides an overall picture of instrument operation. The circuit reference designation for each electronic component in the instrument is shown on the circuit diagrams along with important voltages and waveforms. The following list shows the circuit numbers and their associated circuit in this instrument:

1– 49	Time-Base A Trigger
50– 99	Time-Base B Trigger
100–199	TIME-BASE A Generator
200–299	TIME-BASE B Generator
300–329	External Horizontal Amplifier
330–399	Horizontal Amplifier
400–459	Delay Pickoff
460–599	Vertical Amplifier
600–799	Power Supply
800–869	CRT Circuit
870–899	Calibrator

Switch Wafers

Switch wafers shown on the schematic diagrams are coded to indicate the position of the wafer in the complete switch assembly. The number portion of the code refers to the wafer number counting from the front or mounting end of the switch toward the rear. The letters 'F' and 'R' indicate whether the front or rear of the wafer is used to perform the particular switching function.

Wiring Color-Code

All wiring in the Type RM545B is color-coded to facilitate circuit tracing. The widest color stripe identifies the first color of the code. The background color indicates the following: white—positive voltage, tan—negative voltage, gray—unregulated voltage.

The regulated power-supply wiring is identified by the following code:

+500 volts . . . . . Green-black-brown on white background.
+350 volts . . . . Orange-green-brown on white background.
+225 volts . . . . . Red-red-brown on white background.
+100 volts . . . . .Brown-black-brown on white background.
–150 volts . . . . . .Brown-green-brown on tan background.

Type RM545B is not color-coded in any particular manner; the color used is to facilitate point-to-point circuit tracing within the instrument.

Resistor Color-Code

Composition resistors used in this instrument are color-coded according to the EIA color code. Some stable metal-film resistors are also used. These resistors can be identified by their gray body color. If a metal-film resistor has a value indicated by three significant figures and a multiplier, it is color-coded according to the EIA standard. If it has a value indicated by four significant figures and a multiplier, the value is printed on the body of the resistor. For example, a 333 kΩ resistor is color-coded, but a 333.5 kΩ resistor has its value printed on the resistor body. The color coding is shown in Fig. 4-5, and listed in Table 4-1.

TABLE 4-1

Color Code Sequence

Color	1st Sig. Fig.	2nd Sig. Fig.	3rd Sig. Fig.	Multiplier	(±) % Tolerance
Black	0	0	0	1	
Brown	1	1	1	10	1
Red	2	2	2	100	2
Orange	3	3	3	1,000	
Yellow	4	4	4	10,000	
Green	5	5	5	100,000	0.50
Blue	6	6	6	1,000,000	0.25
Violet	7	7	7	10,000,000	0.10
Gray	8	8	8	100,000,000	0.05
White	9	9	9	1,000,000,000	
Gold				0.1	5
Silver				0.01	
No color					10

TROUBLESHOOTING

General Information

The following information is provided to facilitate troubleshooting. Information contained in this section of the manual should be used in conjunction with information obtained from other portions of the manual.

In general, instrument troubleshooting can be divided into two parts: isolating the trouble to the defective circuit, and the actual location of the defective component. The following general procedures should help isolate the trouble to the defective circuit. Then the circuit troubleshooting information should be used to locate the defective component.

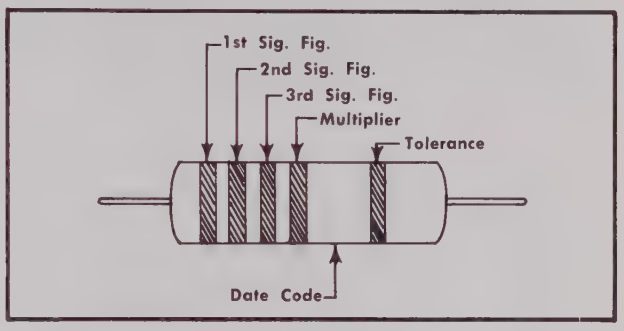


Fig. 4-5. Standard EIA color code for metal-film resistors.

Circuit Isolation

The circuitry in this instrument consists of 11 major sections, as follows:

Time-Base A Trigger
Time-Base B Trigger
Time-Base A Generator
Time-Base B Generator
External Horizontal Amplifier
Horizontal Amplifier
Delay Pickoff
Vertical Amplifier
Power Supply
CRT Circuit
Calibrator

If the instrument does not operate at all, check the obvious things first. Check to see the instrument is plugged in and there is power at the socket. Check the line fuse. Check that the pilot lamp and tube heaters are lit. When the obvious indications of trouble have been checked, proceed to a more detailed analysis of the trouble.

When a trouble occurs in the instrument, first recheck the settings of all controls to see that they are set properly. Then turn the front-panel controls throughout their range to see what effect, if any, they have on the trouble symptom. The normal or abnormal operation of each control may help to indicate the circuit in which the trouble is located.

When vertical-system troubles are encountered, isolate the trouble to either the oscilloscope or to the vertical plug-in unit. One way to do this is by substituting another vertical plug-in unit. If the trouble appears to be in the plug-in unit, refer to the Maintenance section of the plug-in unit instruction manual.

It is possible for an incorrect voltage to affect one circuit more than another. Consequently, a power supply trouble should be considered as a possibility in virtually any type of failure which may occur within the instrument. If there is any doubt as to whether a power supply may be causing the trouble, the regulated output and ripple of that supply should be checked before proceeding further with the troubleshooting procedure. If the output voltage and ripple of a regulated power supply are correct, that supply can be assumed to be operating properly.

Although the instrument is stable, it is possible for circuits to get out of calibration, thereby producing an apparent trouble. Before proceeding with any detailed trouble analysis, be sure that the trouble cannot be corrected by means of a normal calibration adjustment. If there is any doubt, recalibrate the entire suspected circuit using the procedure given in Section 5.

Circuit Troubleshooting

After the trouble has been isolated to a particular circuit, perform a complete visual check of that circuit. Some troubles can be found most easily by visual means. If a visual check fails to detect the cause of the trouble, check the tubes or transistors used in that circuit by replacing them with tubes or transistors known to be good. Be sure to return good tubes and transistors to their original sockets. If the trouble is not the result of a tube or transistor failure, use the following procedure.

1. Isolate the trouble to a portion of the circuit if possible.

2. Recheck the reaction of the front-panel controls and calibration adjustment on the affected circuit.

3. Check the voltage in the circuit. Typical operating voltages are given on the schematic diagrams.

4. Check waveforms in the circuit, using a test oscilloscope. Typical waveforms are given on the schematic diagrams.

5. Check the components in the circuit (i.e., check for faulty capacitors, off-tolerance resistors, etc.).

NOTES

SECTION 5
PERFORMANCE CHECK CALIBRATION

Change information, if any, affecting this section will be found at the rear of the manual.

Introduction

The Type RM545B Oscilloscope (hereafter called Oscilloscope) should be cleaned, checked and/or calibrated every 500 operating hours or every six months, whichever occurs first.

A Short Form Procedure is contained at the beginning of the procedure. It refers to each step by number and gives the name and a brief description of the adjustment or check performed. It can, therefore, be used as a short-form performance check or calibration procedure for a person who is experienced in calibrating the Type RM545B. Duplicating the calibration record and index will allow copies of it to be used as a permanent check-off list and calibration record, leaving the original as an unmarked reference for rapid location of individual checks or adjustments.

Procedure Format

Equipment setup pictures are provided to show a recommended arrangement of equipment during sections of the procedure. Accompanying tables list control settings to facilitate performance of partial procedures. When a complete procedure is being performed, the setup tables need only be referred to when specifically directed by the text.

The names of the Type RM545B Oscilloscope controls are written in capital letters wherever they appear. Test equipment controls have only their first letter capitalized. The terms "Oscilloscope" and "Test Oscilloscope" differentiate between the Type RM545B and the test oscilloscope used in the procedure.

Illustrations

The Type RM545B is essentially a Type 545B which is rotated clockwise 90° before the front panel is attached. All pictures appearing in this procedure are of a 545B, and apply equally to the RM545B, making allowance for the rotation. The top becomes the right side, the left side becomes the top, etc.

Calibration Procedure.

When performed in its entirety, this procedure permits a technician to calibrate the instrument to the specifications listed in Section 1. All adjustments except the −150 VOLTS should be made as accurately as possible to provide optimum results. If the requirements of any of the steps cannot be met, recheck the setups; then troubleshoot the Oscilloscope as necessary to find and correct the trouble. When a complete procedure is being performed, INTERACTION comments may be ignored unless otherwise specified.

Performance Check

By performing only applicable parts of the procedure, a Performance Check can be made without removing the instrument covers. The Performance Check compares the Oscilloscope operation with the specifications given in Section 1. If any of the checks do not meet specified requirements, the Calibration Procedure should be performed on at least the applicable area.

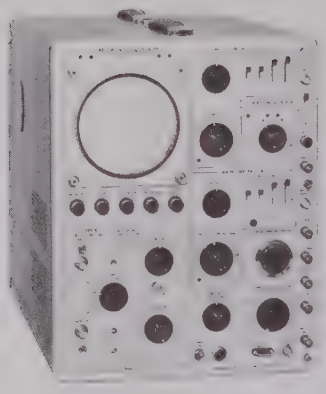
Partial Procedure

To perform a partial procedure, observe the setup instructions which precede the applicable step. Any INTERACTION adjustments listed at the end of the step must also be performed.

EQUIPMENT REQUIRED

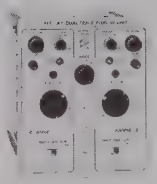
The following equipment or its equivalent is required to perform the complete calibration procedure. Test equipment specifications are the minimum necessary for accurate calibration of the Oscilloscope. All test equipment is assumed to be correctly calibrated and operating within its specified tolerances. If test equipment is substituted, it must meet or exceed the specifications of the recommended equipment, and the procedure must be altered as required by the substitute equipment.

Special calibration fixtures are used where necessary. All calibration fixtures listed here can be obtained through a Tektronix Field Office or Representative.

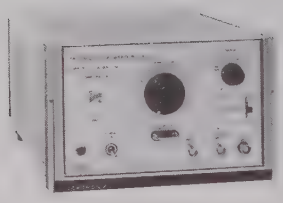


(1)

(2)

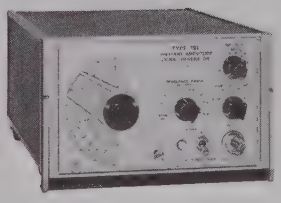


(3)

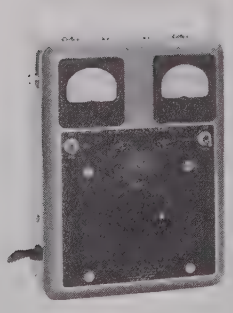


(4)

(5)



(6)



(7)

(8)

(9)

Fig. 5-1. Equipment used in this procedure.

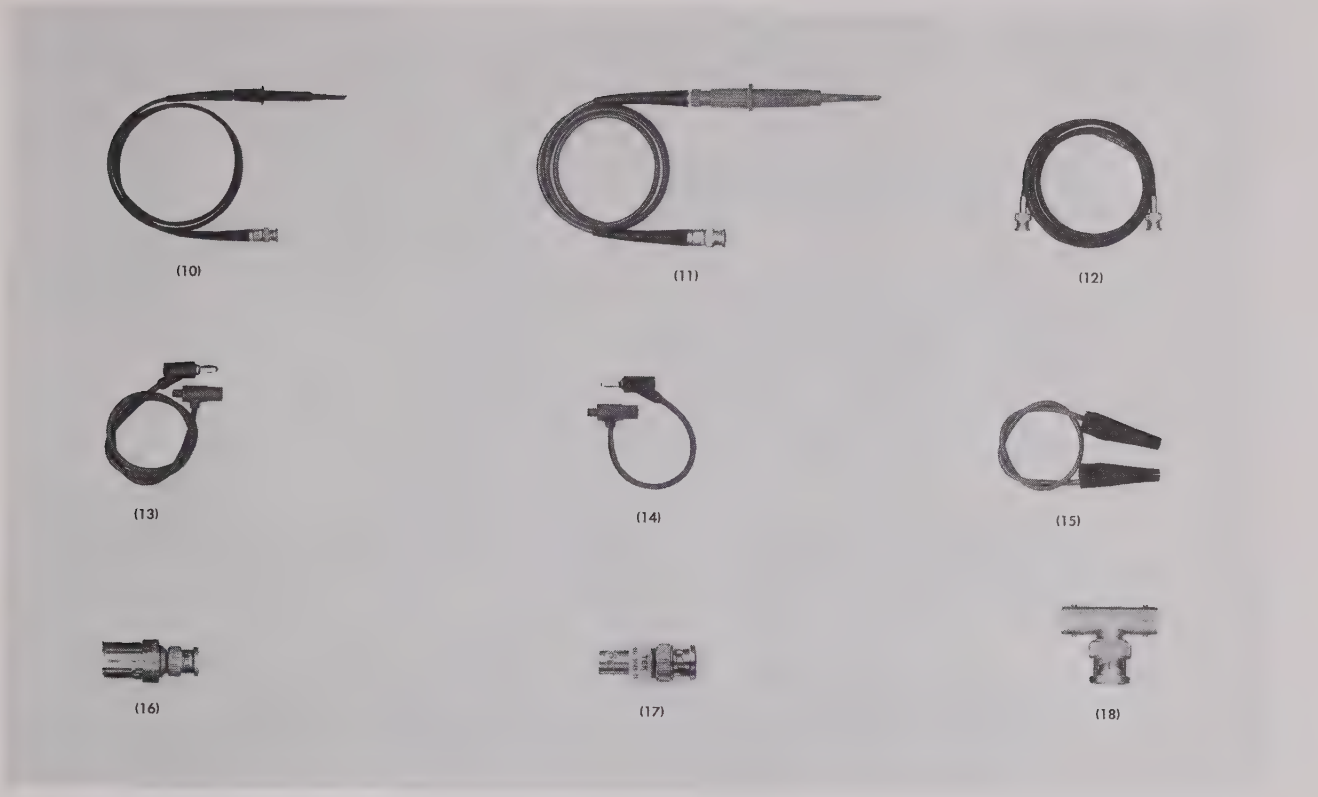


Fig. 5-2. Accessories used in this procedure.

1. Test Oscilloscope. Bandwidth of DC to 10 MHz; Vertical deflection factor range 5 mV/division through 20 V/division. Any 10 MHz oscilloscope can be used. A Tektronix Type 547 with Type B Plug-In Unit appears in the accompanying pictures.

2. Load/Pulser Calibration Fixture Plug-In Unit. Tektronix Part No. 067-0521-01 recommended. Tektronix Calibration fixture 067-0521-00, or 1 M1, or TU-7 can be substituted when calibrating Oscilloscopes below serial number 10730.

3. Tektronix Type 1A1 Vertical Plug-In Unit.

4. Standard Amplitude Calibrator. Amplitude accuracy within 0.25%; signal amplitude 0.1 volt through 100 V in 1-2-5 steps; output signal — 1 kHz square wave; also capable of providing a 100 V—DC output. Tektronix Amplitude Calibrator and Comparator Part No. 067-0502-01 recommended.

5. Time Mark Generator. Marker outputs of 5 seconds through 10 nanoseconds in 5-2-1 steps; sine wave output of 20 MHz (50 nanoseconds). Tektronix Type 184 Time Mark Generator recommended.

6. Constant Amplitude Signal Generator. Frequency 350 kHz to over 33 MHz with a 50 kHz reference frequency. Variable output from 5 mV to 5 V into 50 Ω termination (10 V unterminated). Amplitude accuracy within ± 3% at 50 kHz and 350 kHz. Tektronix Type 191 Constant Amplitude Signal Genrator recommended.

7. Variable Autotransformer. Capable of providing applicable voltage range as listed in Table 5-3. Output voltage monitored by an AC (RMS) voltmeter. Power handling capability of at least 600 watts. For example - General Radio W10MT3W Metered Variac Transformer.

8. Low Frequency Signal Generator. Frequency 30 Hz to 350 kHz. For example, General Radio Oscillator Type 1310-A.

9. DC Voltmeter. 20,000 Ω/V minimum sensitivity rating. Accuracy checked to within 1% at 100, 150, 225, 350 and 500 V; accurate to within 3% at 1700 V.

10. 1X Probe. Tektronix P6011 or P6028 recommended. Part Nos. 010-0193-00 and 010-0074-00 respectively.

11. 10X Probe. If a Type B Plug-In Unit is being used with the Test Oscilloscope, Tektronix P6006 or P6012 recommended; Part Nos. 010-0127-00 and 010-0203-00, respectively. Otherwise, the probe selection must be based on the Test Oscilloscope Vertical input capacitance.

12. Coaxial cable, 2 each; 50 Ω impedance; 42 inches long; BNC connectors; Tektronix Part No. 012-0057-01.

13. Patch Cord, 18 inches long; BNC to banana plug connectors. Tektronix Part No. 012-0091-00.

14. Patch Cord. 6 inches long; BNC to banana plug connectors. Tektronix Part No. 012-0088-00.

15. Jumper wire. 4 inches long (approximate); miniature alligator clips on each end.

16. Adapter, GR to BNC-male; Tektronix Part No. 017-0064-00.

17. In-line termination. 50 Ω impedance; accurate to within 3%; BNC connectors. Tektronix Part No. 011-0049-01.

18. BNC T connector. Tektronix Part No. 103-0030-00.

19. Adjustment tools (not shown).

Description	Tektronix Part No.
Low capacitance screwdriver; 3 inch shaft	003-0047-00
Screwdriver; 3 inch shaft, 3/32 inch bit	003-0192-00
Hexagonal key wrench; 1/16 inch	003-0106-00
Tuning tool handle	003-0307-00
Insert for 5/64 (ID) hex cores	003-0310-00

SHORT FORM PROCEDURE

The following procedure should be performed with the applied voltage at the center of the range for which the Oscilloscope power supply is connected, unless otherwise specified.

1. (Calibration Procedure only). Check/Adjust Low-Voltage Power Supply Voltages. (−150 VOLTS, R616)

   Limits as follows: −150 V ±4.5 V; +100 V ±3.0 V; +225 V ±6.75 V; +350 V ±10.5 V; +500 V ±25 V.

   Adjust −150 VOLTS only as necessary to have all supplies within tolerance.

2. (Calibration Procedure only). Check Low Voltage Power Supply Regulation.

   Should remain within voltage and ripple limits with applied voltage at each extreme of applicable range as listed in Tables 5-2, 5-3 and 5-4.

3. (Calibration Procedure only. Adjust High Voltage Power Supply; (High Voltage, R840); Check High Voltage Power Supply Regulation.

   High Voltage −1700 V ±51 V throughout applicable line voltage range.

4. Check/Adjust Trace Alignment (TRACE ROTATION, R778)

Trace should be parallel to horizontal graticule lines.

5. Check/Adjust Geometry (GEOMETRY, R861).

Bowing within 1.5 mm on vertical lines; within 2 mm on horizontal lines.

6. Check/Adjust AMPLITUDE CALIBRATOR accuracy (CAL ADJ. R879).

Adjust at 100 VOLTS; accuracy within 3% at all positions.

7. Check Amplitude Calibrator Repetition Rate and Symmetry

Positive pulse should be within 45 to 55% of period time.

8. Check/Adjust Vertical Amplifier DC Balance (DC BAL, R495).

Trace within ±2 cm of graticule center with vertical inputs shorted together.

9. Check/Adjust Vertical Amplifier Gain (GAIN, R520)

0.1 V input should cause 1 cm vertical deflection.

10. Check Gain Change with Line Voltage Change.

Not more than 1% gain change should result from line voltage change over range given in Table 5-3.

11. Check Low-Frequency Vertical Linearity

2 cm display should not compress or expand more than 1.5 mm when moved from graticule center to top or bottom of the graticule.

12. Check Trace Drift Resulting from Line Voltage Change.

Trace should not drift more than 1 cm when line voltage is changed from limit to limit within applicable voltage range.

13. Check Alternate Trace Operation

Trace should alternate at all sweep rates with Alternate selected at the Vertical Plug-In Unit.

14. Check Dual Trace Chopped Blanking

DUAL TRACE CHOPPED BLANKING position of the CRT CATHODE SELECTOR switch should diminish intensity of Vertical Plug-In Unit chopping transients.

15. (Calibration Procedure only). Adjust Time Base A Trigger Level Centering (TRIG LEVEL CENTERING, R39).

Should trigger in EXT + and — slope with R19-R20 junction grounded. STABILITY below free-running threshold, and 0.2 V square wave applied to A TRIGGER INPUT.

16. (Calibration Procedure only). Adjust A Internal Trigger DC Level (INT TRIG DC LEVEL, R3). Check/Adjust A TRIGGERING LEVEL knob position.

With set-up as in step 15, should trigger in + and — INT.

With grounding jumper removed, TRIGGERING LEVEL knob should point to within a few degrees of 0 while triggering occurs.

17. (Calibration Procedure only) Check/Adjust A Trigger Sensitivity (TRIG SENS, R47).

AUTO trigger multivibrator output should be symmetrical as observed at Q45-C.

18. (Calibration Procedure only). Adjust Time Base A Preset (PRESET ADJUST, R111).

With LINE triggering selected, PRESET ADJUST should be set midway between triggering and free run as determined by display brightness and voltmeter connected to wiper of PRESET ADJUST potentiometer, R111.

19. (Calibration Procedure only) Adjust B Trigger Level Centering (TRIG LEVEL CENTERING, R82).

Should trigger in EXT + and — slopes with R69-R70 junction grounded, STABILITY below free-running threshold, and 0.1 V square wave applied to B TRIGGER INPUT.

20. (Calibration Procedure only). Adjust B Internal Trigger DC Level (INT TRIG DC LEVEL, R53); Check/Adjust B TRIGGERING LEVEL Knob Position.

With set-up as in step 19, should trigger in + and — INT.

With grounding jumper removed, TRIGGERING LEVEL knob should point to within a few degrees of 0 while triggering occurs.

21. (Calibration Procedure only). Adjust Time Base B Preset (PRESET ADJUST, R211).

With LINE triggering selected, PRESET ADJUST should be set midway between triggering and free run as determined by display brightness and voltmeter connected to wiper of PRESET ADJUST potentiometer, R211.

22. (Calibration Procedure only). Adjust Lock-Out Level (LOCK-OUT LEVEL ADJUST, R125).

In triggered 'A' DLY'D BY 'B' mode, V125-pin 2 waveform observed on Test Oscilloscope should have following amplitude: square-wave portion — 11 V; sawtooth portion — 9 V.

23. Check Time Base A and B Low-Frequency Triggering Sensitivity.

Triggering should occur under setups listed in Table 5-8.

24. Check Time Base A and B Triggering Response at Mid and High Frequency.

Triggering should occur under setups listed in Table 5-9.

25. Check Time Base A Single Sweep Operation.

READY lamp lights when RESET button is pressed; light extinguishes after a single sweep occurs.

26. Check Line Triggering.

Stable triggering with correct polarity should be obtained in + and — LINE when displaying a line-frequency signal.

27. Check/Adjust 5X Magnifier Gain (MAG GAIN, R375).

With 5X MAGNIFIER ON, TIME BASE B and 1 mSEC/CM selected, and .1 ms time markers displayed, 2 markers per cm should be displayed. 4 mm total deviation allowed between markers at 2nd and 10th vertical line.

28. Check/Adjust Sweep Registration (NORM/MAG REGIS, R358)

Marker aligned to center vertical graticule line should not shift more than 0.5 cm as 5X MAGNIFIER is turned on or off.

29. Check/Adjust B Time Base Sweep Length (MAX SWP LENGTH, R277; MIN SWP LENGTH, R273).

Maximum and minimum sweep lengths should be more than 10 and less than 5, respectively. Adjust for maximum and minimum sweep lengths of approximately 10.5 and 3.5 cm, respectively.

30. Check/Adjust B Time Base Unmagnified Slow Sweep Rate Accuracy (SWEEP CAL, R348).

With TIME BASE B, 1 mSEC/CM, and 1 mSEC time marks selected, 1 marker per cm should be displayed. 2.4 mm total deviation allowed between markers at 2nd and 10th vertical lines. Adjust at 1 mSEC/CM; check at all slower sweep rates.

31. Check/Adjust Horizontal Amplifier Input Compensation (C330)

With 5X MAGNIFIER ON, trace should start within 5 mm of same position on the graticule when the B TIME/CM switch is changed from .1 mSEC to 50 μSEC.

32. Check/Adjust A Sweep Length (SWEEP LENGTH, R176).

With HORIZONTAL DISPLAY switch at A, sweep length at 1 mSEC should be 10.5 cm ±3 mm.

33. Check Time Base A VARIABLE TIME/CM.

With VARIABLE fully counterclockwise, TIME/CM at 1 mSEC, 2 cm or less separation should exist between applied 5 ms markers.

34. Check/Adjust A Time Base Unmagnified Slow Sweep Rate Accuracy (R160Z).

With TIME BASE A and 1 mSEC/CM selected VARIABLE at CALIBRATED and 1 ms time marks applied, 2.4 mm total deviation allowed between markers at 2nd and 10th vertical lines. Timing between 2nd and 10th markers at 1 mSEC/CM on A and B sweeps should be matched to within 5 mm.

Check timing at all slower sweep rates.

35. Check/Adjust A Time Base Fast Sweep Rates (C160A, C375, C348, C160C, C160E).

2.4 mm total deviation allowed between markers displayed at 2nd and 10th vertical graticule lines at sweep rates faster than 1 mSEC/CM. Setups and adjustment information listed in Table 5-12.

36. Check/Adjust Delay Accuracy (DELAY START R436, DELAY STOP R432).

With 'B' INTENSIFIED BY 'A', .1 μSEC/CM A sweep rate, and 1 mSEC/CM B sweep rate selected, the DELAY TIME MULTIPLIER DIAL should read 1.00 ±.03 and 9.00 ±.11 with top of markers associated with 2nd and 10th vertical lines (respectively) intensified. Adjust as necessary, using 'A' DLY'D BY 'B' mode.

37. Check/Adjust Time Base B Fast Sweep Delay Accuracy (C260C, C260A).

Adjust C260C with Time Base A at 2 μSEC, Time Base B at 50 μSEC, and 50 μSEC, markers applied; Adjust C260A with Time Base A at .2 μSEC, Time Base B at 5 μSEC, and 5 μs markers applied.

Check for 8.00 ±.12 dial divisions difference between markers associated with the 1.00 and 9.00 DELAY-TIME MULTIPLIER dial settings at all B sweep rates.

38. Check Time Base B Unmagnified Fast Sweep Displayed Accuracy

With B display of 1 or 2 markers per cm, total deviation of markers at 2nd and 10th vertical graticule line should be within ±2.4 mm at sweep rates of .5 mSEC through 2 μSEC.

39. Check Delay-Time Jitter

In 'A' DLY'D BY 'B' mode, with B TIME/CM at 1 mSEC, A TIME/CM at 1 μSEC and 1 mS time marks applied, horizontal jitter of displayed time mark should not exceed 5 mm.

40. Check/Adjust External Horizontal Amplifier DC Balance (EXT HORIZ DC BAL, R317).

In EXT X1 mode with signal applied to HORIZ INPUT connector, ground reference should not shift more than 2 cm with full-range rotation of VARIABLE 10-1 control.

41. Check/Adjust External Horizontal Amplifier X10 Input Compensation (C301C).

Horizontal aberration difference between same amplitude EXT X10 and EXT X1 square wave displays should be within 5% of total horizontal display amplitude.

42. Check External Horizontal Amplifier Deflection Factor

0.2 V or less per cm in X1 position; 2 V or less per cm in X10 position; VARIABLE 10-1 must have a range of 10:1 or greater.

43. Check Horizontal Amplifier Bandwidth

Horizontal deflection of 350 kHz signal should be at least 70% of deflection caused by same amplitude 50 kHz signal.

44. Check/Adjust Vertical Amplifier High Frequency Compensation (R502, R578, R551, L560, C577, C551, C568, L589, L599, R580, C520, C581 L554, L588, L598).

Adjust in accordance with Table 5-18.

45. Check Risetime

Risetime of 5 cm fast-rise square wave should not exceed 10 ns.

46. Check + GATE A and + GATE B Front Panel Outputs

+ GATE outputs 20 V or greater, positive going with 0-V baseline; A gate duration should be approximately 10.5 times the selected A TIME/CM with VARIABLE at CALIBRATED; B gate duration should be 10.5 times the selected B TIME/CM with B LENGTH fully clockwise, and should decrease with counterclockwise movement of LENGTH knob.

47. Check SAWTOOTH A Front Panel Output.

130 V or greater in amplitude, positive-going, with same time duration as the A Time Base.

48. Check VERT SIG OUT Front Panel Output

1.2 V or greater output for each cm of display amplitude.

49. Check DLY'D TRIG Front Panel Output

Positive-going pulse of approximately 5 V amplitude occurring at end of delay period.

50. Check Vertical Amplifier Bandwidth

Vertical deflection of 33 MHz signal applied through Type 1A1 should be at least 70% of deflection caused by same amplitude 50 kHz signal.

DETAILED PROCEDURE

Preliminary

a. (Calibration Procedure only) Slide the Oscilloscope out on its tracks.

b. Install the Load/Pulser Calibration Fixture Plug-In Unit. (Item 2). (This unit will hereafter be called the Calibration Fixture.)

c. Set the Oscilloscope and Calibration Fixture front-panel controls as listed in Table 5-1.

d. Set the Autotransformer (item 7) to the center of the range of the nominal line voltage indicated on the Line Voltage Selector at the back of the Oscilloscope. On instruments below serial number 8880, the applicable line voltage must be determined by comparing the transformer connections against Fig. 2-2 in the Operating Instructions section.

e. Connect the Oscilloscope power cord to the Autotransformer output.

f. Connect the Autotransformer to a suitable power source.

g. Turn the Oscilloscope INTENSITY fully counterclockwise.

h. Energize all test equipment to be used in the procedure.

i. CHECK—Delay time of the delay relay. Turn the Oscilloscope POWER switch ON. The relay armature should activate with an audible click within 15 to 60 seconds.

j. Adjust the Oscilloscope INTENSITY, FOCUS and ASTIGMATISM as necessary to obtain an optimum display.

k. Allow at least 20 minutes warmup at ambient temperature of 25°C (±5°C) before checking the instrument to given accuracy.

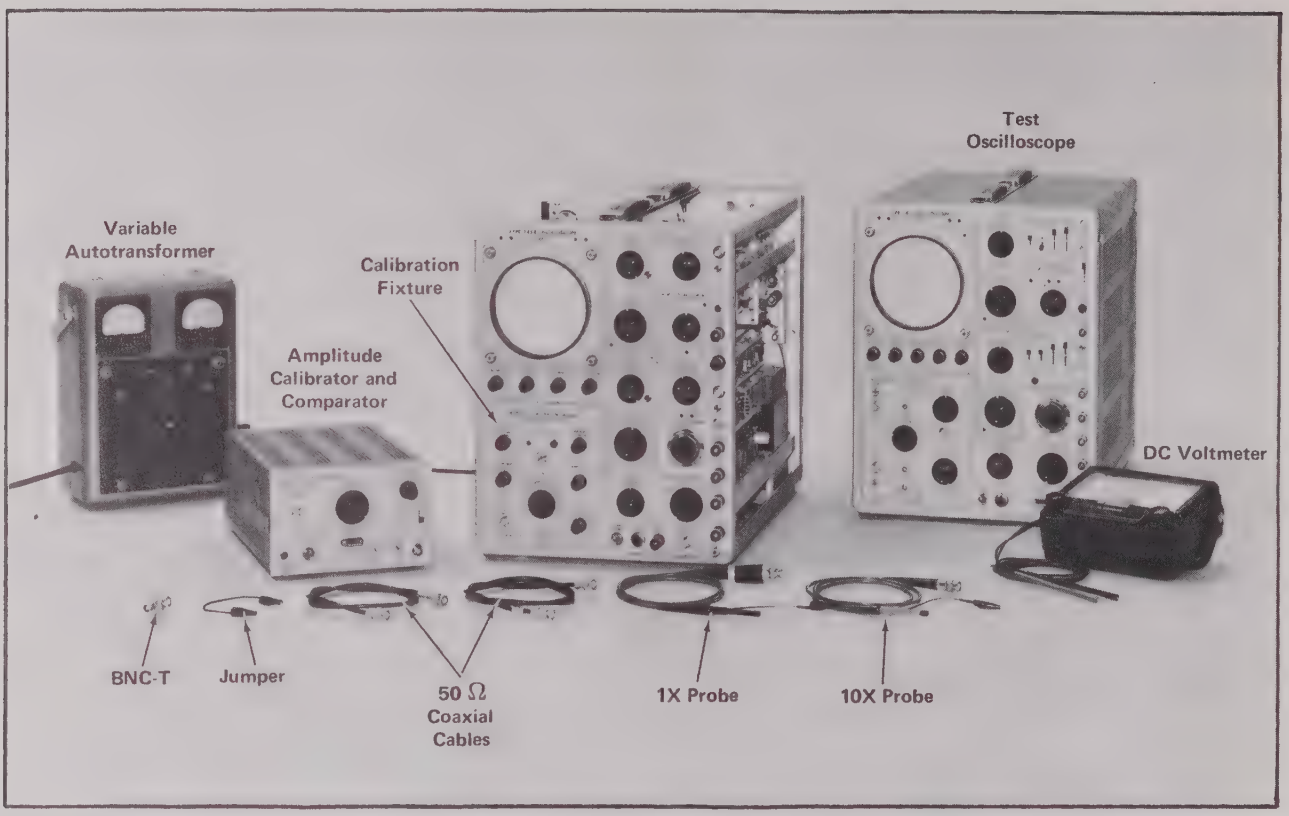


Fig. 5-3. Basic setup of equipment for steps 1 through 22.

TABLE 5-1

Control Settings for Steps 1 through 22

Oscilloscope	
HORIZONTAL DISPLAY	A
5X MAGNIFIER	OFF
Time Base A Controls	
TIME/CM	1 mSEC
VARIABLE	CALIBRATED
STABILITY	Fully CW
TRIGGERING LEVEL	Fully CW
TRIGGER SLOPE	+INT
TRIGGERING MODE	AC
Time Base B Controls	
TIME/CM	1 mSEC
LENGTH	10 CM
STABILITY	Fully CW
TRIGGERING LEVEL	Fully CW
TRIGGER SLOPE	+INT
TRIGGERING MODE	AC
DELAY-TIME MULTIPLIER 1-10	1.00
AMPLITUDE CALIBRATOR	OFF
HORIZONTAL POSITION	Midrange or centered display

Calibration Fixture	
Test Function	Low Load
Variable	CCW
Vertical Position	Midrange
Amplitude	CCW
Repetition Rate	4 kHz or Low

1. (Calibration Procedure only). Check/Adjust Low Voltage Power Supply Voltages (−150 VOLTS, R616)

NOTE

The −150 V supply controls all of the power supplies. Adjust it only in accordance with step c.

a. Equipment setup appears in Fig. 5-3 and Table 5-1.

b. CHECK each power supply voltage against the voltage tolerances listed in Table 5-2, using a DC voltmeter (item 9). Test point locations are shown in Fig. 5-4B.

TABLE 5-2

Power Supply Voltage Limits

Supply	Tolerance
−150 V	± 4.5 V
+100 V	± 3.0 V
+225 V	± 6.75 V
+350 V	±10.5 V
+500 V	±25.0 V

c. ADJUST—150 VOLTS R616 (Fig. 5-4A) as necessary to bring all power supplies within tolerance. Do not refine the −150 VOLTS adjustment if all the power supplies are within allowable limits.

2. Check Low Voltage Power Supply Regulation

REQUIREMENT: Regulation within limits given in Table 5-2 must exist for line voltages which are within ±10% of center voltage value for which the oscilloscope is connected.

NOTE

Readjust the −150 VOLTS only as necessary to have all low-voltage power supply values meet the specification listed in this step. Adjustment of −150 VOLTS requires that the complete Calibration Procedure be performed.

a. Basic arrangement of equipment appears in Fig. 5-3. Control settings are listed in Table 5-1.

b. Calibration Procedure only:

(1) Set the Autotransformer for an output equal to the applicable upper voltage value listed in Table 5-3.

(2) CHECK—Voltages. Using the DC voltmeter, check that each supply voltage (Fig. 5-4B) is within the limits specified in Table 5-2.

TABLE 5-3

Operating Voltages

Nominal Voltage	Range Selector	Voltage Range	Center Voltage
Oscilloscopes Serial Number 8880 and above			
115 V	LO	90 - 110	100
	M	104 - 126	115
	HI	112 - 136	124
230 V	LO	180 - 220	200
	M	208 - 252	230
	HI	224 - 272	248
Oscilloscopes below Serial Number 8880 (See Fig. 2-2 in the Operating Instructions section for transformer wiring information)			
115 V		97.2 - 118.8	108
		103.5 - 126.5	115
		109.8 - 134.2	122
230 V		194.4 - 237.6	216
		207.0 - 253.0	230
		219.6 - 268.4	244

(3) ADJUST— −150 VOLTS as necessary to bring all values within tolerance specified in Table 5-2.

(4) CHECK—Ripple. Using the Test Oscilloscope (item 1), 1X probe (item 10), AC Input coupling, 5 mV/div vertical deflection factor, and 5 ms/div sweep rate, check that the peak-to-peak ripple of each supply is within the limits listed in Table 5-4. Test point locations appear in Fig. 5-4B. Connect a short probe-grounding lead between the probe grounding contact and the Oscilloscope chassis during the check.

TABLE 5-4

Power Supply Ripple Limits

Supply	Limit (Peak-to-Peak)
−150 V	5 mV
+100 V	15 mV
+225 V	5 mV
+350 V	20 mV
+500 V	20 mV

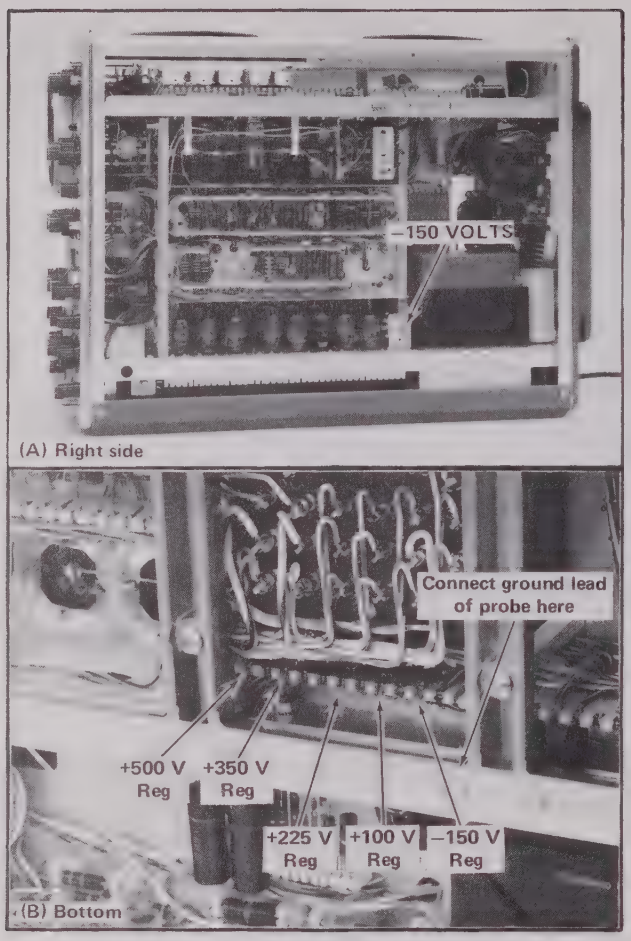


Fig. 5-4. Adjustment of test point locations, steps 1 and 2.

(5) Set the Autotransformer for an output equal to the applicable lower voltage value listed in Table 5-3.

(6) Set the Calibration Fixture to High Load.

(7) Repeat steps (2), (3) and (4). If re-adjustment is necessary, repeat step 2 in its entirety.

c. Performance Check only:

(1) Connect a 50 Ω coaxial cable (item 12) from the Oscilloscope CAL OUT jack to the Calibration Fixture EXT Input jack.

(2) Set the AMPLITUDE CALIBRATOR switch to 2 VOLTS.

(3) Check that the Autotransformer is set for an output equal to the center line voltage for which the Oscilloscope is wired. See Table 5-3.

(4) Set the Calibration Fixture Test Function switch at Low Load and set the Variable control for a 2 cm display. Adjust the Oscilloscope TIME BASE A STABILITY and TRIGGERING LEVEL controls as necessary to obtain a stable display.

(5) Set the Autotransformer for an output equal to the applicable upper voltage value listed in Table 5-3.

(6) CHECK—Regulation. The display should remain stable, with no appreciable change in display amplitude. Not more than 0.5 cm drift should occur.

(7) Set the Autotransformer for an output equal to the applicable lower voltage value listed in Table 5-3.

(8) Set the Test Function switch to High Load.

(9) CHECK—Regulation. The display should remain stable with no appreciable change in display amplitude. Not more than 0.5 cm drift should occur.

(10) Disconnect the cable form the Oscilloscope CAL OUT connector.

(11) Turn the TIME BASE A STABILITY and TRIGGERING LEVEL controls fully clockwise.

d. Set the Autotransformer output to the Oscilloscope applicable center line voltage and turn the Calibration Fixture Test Function switch to Low Load.

e. INTERACTION—Adjustment of the –150 VOLTS requires that a complete Calibration Procedure be performed on the Oscilloscope.

3. (Calibration Procedure only) Adjust High Voltage Power Supply; Check High Voltage Power Supply Regulation (High Voltage, R840)

a. Equipment setup appears in Fig. 5-3 and in Table 5-1.

b. Turn the Oscilloscope off. Then set the DC Voltmeter for a −1700 V input and connect it between the −1700 V check point (Fig. 5-5) and ground.

c. Turn the Oscilloscope on and wait approximately 3 minutes before continuing.

d. Place the Vertical Position control to its clockwise limit, moving the display completely off the face of the CRT.

e. Turn the Oscilloscope INTENSITY fully clockwise.

f. CHECK—Meter reading should be −1700 V ±51 V.

g. ADJUST—HIGH VOLTAGE R840 (Fig. 5-5) for −1700 V.

h. CHECK—Regulation; Set the Variable Autotransformer output voltage to the upper value given within the applicable voltage range in Table 5-3. Check that the high voltage remains within ±51 V of −1700 V for both line voltage values.

i. Return the Autotransformer output to the applicable center line voltage of the Oscilloscope.

j. Adjust the Vertical Position control and the CRT BRIGHTNESS, FOCUS and INTENSITY for an optimum center screen display.

k. Turn the Oscilloscope off and disconnect the DC Voltmeter.

l. Turn the Oscilloscope on and wait 3 minutes before continuing.

m. INTERACTION—Gain, step 9; Horizontal Deflection, steps 27 through 35, 38 and 42.

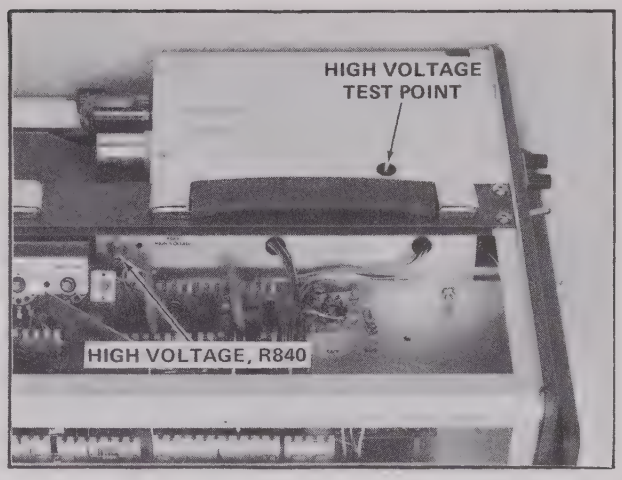


Fig. 5-5. HIGH VOLTAGE TEST POINT and adjustment location, step 3.

4. Check/Adjust Trace Alignment (TRACE ROTATION, R778)

REQUIREMENT—Trace must be adjustable to parallel the horizontal graticule lines.

a. Equipment setup appears in Fig. 5-3 and in Table 5-1.

b. Position the trace directly behind the center horizontal graticule line, using the Calibration Fixture Vertical Position control.

c. CHECK—The trace should be parallel to the center graticule line.

d. ADJUST—TRACE ROTATION R778 (screwdriver adjustment accessible through front-panel ASTIGMATISM control) to move trace parallel to the center horizontal graticule line.

5. Check/Adjust Geometry (GEOMETRY, R861)

REQUIREMENT—Vertical trace should not exceed 1.5 mm bowing; horizontal trace should not exceed 2 mm bowing.

a. The control settings given in Table 5-1 apply. The basic equipment setup appears in Fig. 5-3.

NOTE

Markers from a Time-Mark Generator can be used in place of the Oscilloscope AMPLITUDE CALIBRATOR signal during this procedure if desired.

b. Connect a 50 Ω coaxial cable from the Oscilloscope CAL OUT connector to the Ext Input connector on the Calibration Fixture.

c. Set the Oscilloscope AMPLITUDE CALIBRATOR to 5 VOLTS.

d. Adjust the Calibration Fixture Variable for approximately 4 divisions separation between traces.

e. Adjust the Oscilloscope Time Base A TRIGGERING LEVEL and STABILITY for a triggered square wave display.

f. Set the Variable control on the Calibration Fixture so that the tops and bottoms of the square waves are out of the CRT viewing area. Increase the CRT INTENSITY as necessary to view the vertical lines.

g. CHECK—The vertical lines should be parallel to the vertical graticule lines.

h. (Calibration Procedure only) ADJUST—GEOMETRY (R861, Fig. 5-6) for straightness of vertical lines. Maximum bowing permitted is 1.5 mm in 8 divisions of vertical display.

i. Disconnect the coaxial cable from the EXT INPUT jack. Set the Time Base A STABILITY control fully clockwise to free-run the trace. Adjust for optimum trace intensity and focus.

j. CHECK—Position the trace to the bottom and then to the top of the graticule and check for bowing of the horizontal trace. Bowing should not exceed 2 mm at the top or bottom of the graticule.

k. Disconnect the coaxial cable from the Calibration Fixture.

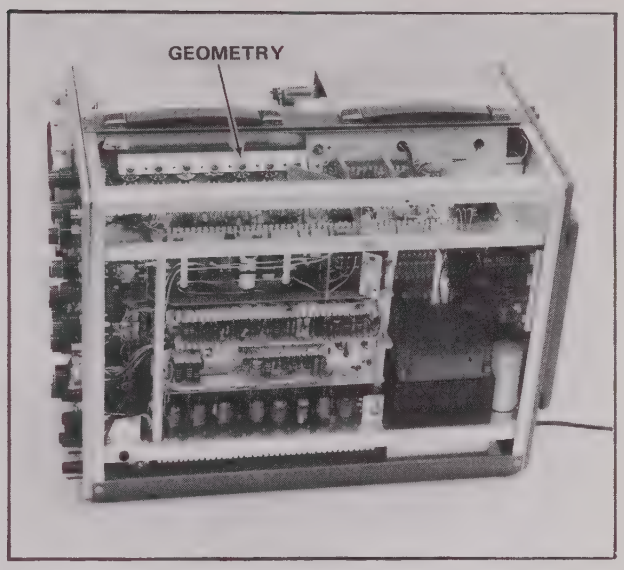


Fig. 5-6. Geometry adjustment location, step 5.

6. Check/Adjust AMPLITUDE CALIBRATOR Accuracy (CAL ADJ, R879)

REQUIREMENT—The amplitude accuracy must be within ±3% of selected value.

a. The control settings in Table 5-1 apply. The basic setup of equipment appears in Fig. 5-3.

b. Connect the 42-inch coaxial cable from the Oscilloscope CAL OUT jack to the Unknown Input of the Standard Amplitude Calibrator (item 4).

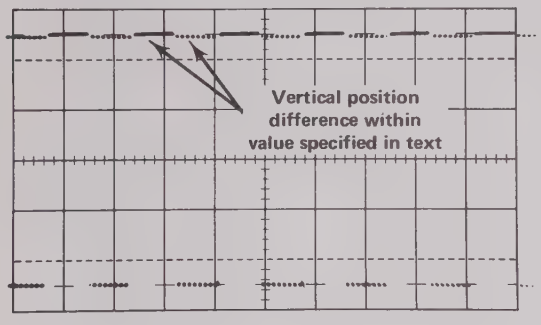
c. Connect a second 42-inch coaxial cable from the Amplitude Calibrator and Comparator Output jack to the Test Oscilloscope vertical input.

d. Set the Amplitude Calibrator and Comparator to +DC Mode Chopped output.

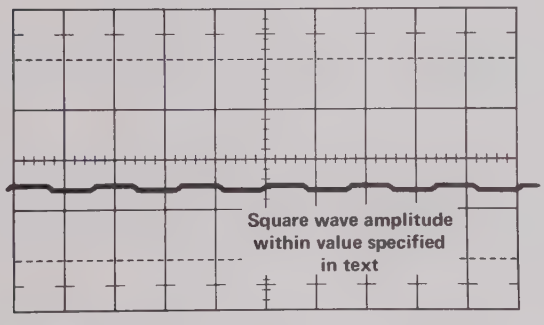
e. Performance Check only:

(1) Select DC vertical input coupling and 10 ms/div horizontal deflection at the Test Oscilloscope.

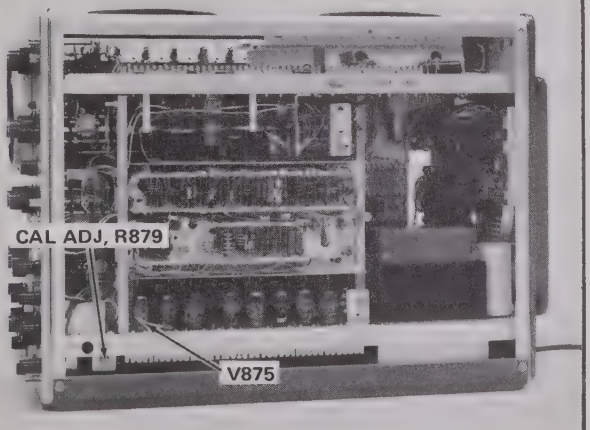
(2) CHECK—Amplitude Calibrator accuracy by comparing the Amplitude Calibrator and Comparator DC voltage against the positive portion of the Oscilloscope AMPLITUDE CALIBRATOR square wave for each setup listed in Table 5-5. Use Fig. 5-7A as a reference waveform.



(A) Performance Check waveform: 10 ms/division sweep rate.



(B) Calibration Procedure waveform; 1 V/division vertical deflection.



(C) Tube and adjustment locations.

Fig. 5-7. Amplitude Calibrator waveforms and adjustment location, step 6.

f. Calibration Procedure only:

(1) Turn the Oscilloscope off. Remove V875 (Fig. 5-7C). Then turn the Oscilloscope on and wait approximately 3 minutes before performing the check in step (5).

(2) Select AC Vertical Input Coupling and 1 volt/division at the Test Oscilloscope.

(3) Set the Amplitude Calibrator and Comparator to 100 V.

(4) Set the Oscilloscope AMPLITUDE CALIBRATOR to 100 V.

(5) CHECK—AMPLITUDE CALIBRATOR 100 V accuracy by comparing the Amplitude Calibrator and Comparator DC voltage against the Oscilloscope AMPLITUDE CALIBRATOR DC voltage as observed on the Test Oscilloscope. A noticeable error will produce a square wave as in Fig. 5-7B. Maximum allowable error is 3 divisions.

(6) ADJUST—AMPLITUDE CALIBRATOR voltage by adjusting CAL ADJ, R879 (Fig. 5-7C) to obtain minimum square wave amplitude. Ideally, the square wave component should be gone from the Test Oscilloscope trace after adjustment.

(7) CHECK—AMPLITUDE CALIBRATOR step accuracy by comparing the Amplitude Calibrator and Comparator voltage against the Oscilloscope AMPLITUDE CALIBRATOR voltage for each setup listed in Table 5-6.

(8) Turn the Oscilloscope off.

(9) Replace V875.

(10) Turn the Oscilloscope on and wait approximately 3 minutes before making the next check.

NOTE

The output accuracy of the remaining positions of the AMPLITUDE CALIBRATOR are dependent upon the same voltage dividers as were checked in this step.

TABLE 5-5

Performance Check of AMPLITUDE CALIBRATOR Accuracy

Test Oscilloscope Volts/Div	Amplitude Calibrator and Comparator (volts)	Oscilloscope Amplitude Calibrator Setting(volts)	Test Oscilloscope Display (divisions)	Vertical Difference at top of Display (divisions)
20	100	100	5	±0.15
10	50	50	5	±0.15
5	20	20	4	±0.12
2	10	10	5	±0.15
1	5	5	5	±0.15
.5	2	2	4	±0.12
.2	1	1	5	±0.15
.1	.5	.5	5	±0.15
.05	.2	.2	4	±0.12
.02	.1	.1	5	±0.15

7. Check Amplitude Calibrator Repetition Rate and Symmetry

REQUIREMENT: Repetition rate—1 kHz ±250 Hz; Symmetry—Positive pulse between 45 and 55% of period time.

a. Equipment setup is continued from step 6.

b. Set the AMPLITUDE CALIBRATOR switch to 1 volt.

c. Set the Amplitude Calibrator and Comparator Output Selector to Unknown (down) position. (The Amplitude Calibrator and Comparator now is being bypassed.)

d. Set the Test Oscilloscope Trigger Slope to +Int, its Time/Div switch to 1 ms, and its Volts/Div to 1.

e. CHECK—AMPLITUDE CALIBRATOR Frequency. The Test Oscilloscope should display between 7.5 and 12.5 cycles in 10 divisions, indicating a repetition rate of 1 kHz ±25%.

f. Set the Test Oscilloscope Time/Div switch to 50 μs and its Variable Time/Div control to display exactly one cycle of the waveform in 10 divisions.

g. CHECK—Width of the positive half cycle should be 5 ±0.5 divisions.

h. Disconnect the coaxial cables from the equipment. Set the Test Oscilloscope Time/Div Variable control to its calibrated position.

8. Check/Adjust Vertical Amplifier DC Balance (DC BAL, R495)

REQUIREMENT: Trace should be within 2 cm of graticule vertical center when the Oscilloscope vertical inputs are shorted together.

a. Control settings given in Table 5-1 apply. Basic setup of equipment appears in Fig. 5-3.

b. Switch the Calibration Fixture Test Function Switch to Common Mode.

c. CHECK—The trace should be within ±2 cm of the center horizontal graticule line.

d. (Calibration Procedure only) ADJUST—DC BAL R495 (Fig. 5-8) to position the trace directly behind the center horizontal graticule line.

TABLE 5-6

Calibration Procedure AMPLITUDE CALIBRATOR Accuracy Check

Test Oscilloscope Volts/Div	Amplitude Calibrator and Comparator	Oscilloscope Amplitude Calibrator	Allowable Square Wave Amplitude (3%)
1	100	100	Adjust for Minimum
.5	50	50	3 div
.2	20	20	3 div
.1	10	10	3 div
.05	5	5	3 div
.02	2	2	3 div
.01	1	1	3 div
.005	.5	.5	3 div
.005	.2	.2	1.2 div
.005	.1	.1	.6 div

9. Check/Adjust Vertical Amplifier Gain (GAIN, R520)

REQUIREMENT—Vertical amplifier gain should be such that 0.1 V at the input causes one cm of vertical deflection.

a. The control settings given in Table 5-1 apply. Equipment setup appears in Fig. 5-3.

b. Change the Calibration Fixture Test Function switch to Gain Set.

c. Connect a 50 Ω coaxial cable from the Amplitude Calibrator and Comparator Output connector to the Calibration Fixture Ext Input connector.

d. Set the Amplitude Calibrator and Comparator Mode switch to Square Wave position, the Output Selector to the "up" position, and the Amplitude switch to 100 Volts.

e. Center the free-running display on the CRT.

f. CHECK—Separation between traces should be 4 cm ±1.2 mm. Measure from trace center to trace center to compensate for trace width.

g. (Calibration Procedure only) ADJUST—GAIN R520 (Fig. 5-8) for exactly 4 cm separation.

10. Check Gain Change with Line Voltage Change

REQUIREMENT—Vertical amplifier gain must not change more than 1% over an input line voltage range as indicated in Table 5-4.

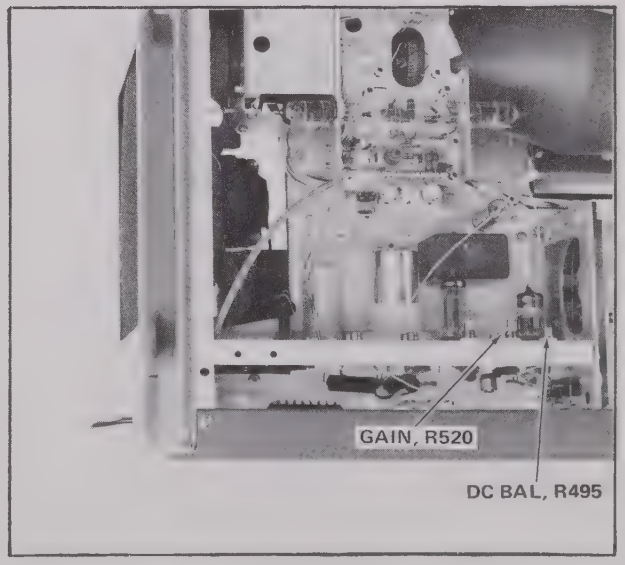


Fig. 5-8. Left side view, showing gain and DC balance adjustment locations, steps 8 and 9.

a. Equipment setup is continued from step 9.

b. Set the Variable Autotransformer output to the high value of the voltage range for which the instrument is wired. See Table 5-3.

c. CHECK—The display must not expand or compress more than 0.4 mm.

d. Set the Variable Autotransformer to the low value of the voltage range for which the instrument is wired. See Table 5-3.

e. CHECK—The display must not compress or expand more than 0.4 mm from the 4 cm value.

f. Set the Variable Autotransformer to the center voltage for which the instrument is wired.

11. Check Low Frequency Vertical Linearity

REQUIREMENT—No more than 1.5 mm vertical compression or expansion of a 2 cm display when positioned over the limits of the vertical scan area.

a. Equipment setup is continued from steps 9 and 10.

b. Set the Amplitude Calibrator and Comparator for 50 volts output. Approximately 2 cm separation between traces should exist on the CRT.

c. Position the display equally above and below the center graticule line.

d. Measure the display amplitude. It will be used as a reference for the following checks.

e. Position the upper trace to the top graticule line.

f. CHECK—Distance between trace centers should be within ±1.5 mm of the value measured in d.

g. Position the lower trace to the bottom graticule line.

h. CHECK—Distance between trace centers should be within ±1.5 mm of the value measured in d.

i. Turn the Amplitude Calibrator and Comparator Amplitude control off.

12. Check Trace Drift Resulting from Line Voltage Change

REQUIREMENT—Not more than 1 cm vertical drift over an input line voltage range as indicated in Table 5-3.

a. The control settings given in Table 5-1 apply.

b. Set the Calibration Fixture Test Function switch to Low Load.

c. Set the Variable Autotransformer output to the low voltage value of the range for which the Oscilloscope is wired. See Table 5-3. Wait 30 seconds and position the trace to graticule center.

d. Change the Variable Autotransformer output to the high voltage value of the voltage range for which the instrument is wired. See Table 5-3.

e. CHECK—After 30 seconds the trace should be within 1 cm of graticule center.

f. Set the Variable Autotransformer to the center voltage for which the instrument is wired.

13. Check Alternate Trace Operation

REQUIREMENT—Trace must alternate at all sweep rates.

a. Set the Calibration Fixture Test Function switch to Alternate.

b. Set the Amplitude Calibrator and Comparator Amplitude to 50 Volts.

c. CHECK—Trace must alternate at all sweep rates. Two distinctly separate traces will occur at .1 μSEC through 1 mSEC/CM, with square waves displayed on the lower trace. The traces will merge at slower sweep rates. At the slowest sweep rates, first the upper trace will be displayed, then the lower trace containing the square wave will be displayed.

d. Set the HORIZONTAL DISPLAY switch to B. Readjust the INTENSITY control as necessary for optimum viewing.

e. CHECK—Trace must alternate at all Time Base B sweep rates in the same manner as explained in c.

f. Set the B TIME/CM switch to 1 mSEC.

g. Set the HORIZONTAL DISPLAY switch to A and disconnect the cable from the Amplitude Calibrator and Comparator.

14. Check Dual Trace Chopped Blanking

REQUIREMENT—DUAL TRACE CHOPPED BLANKING position of the CRT CATHODE SELECTOR switch should diminish intensity of vertical plug-in chopping transients.

a. The control settings given in Table 5-1 apply; basic equipment setup appears in Fig. 5-3.

b. Set the Calibration Fixture Test Function switched to Chopped.

c. Set the A TIME/CM switch to 5 μSEC.

d. Set the A STABILITY and TRIGGERING LEVEL controls for a stable display as in Fig. 5-9A.

e. Set trace intensity for optimum viewing.

f. CHECK—Display should be similar to that in Fig. 5-9A.

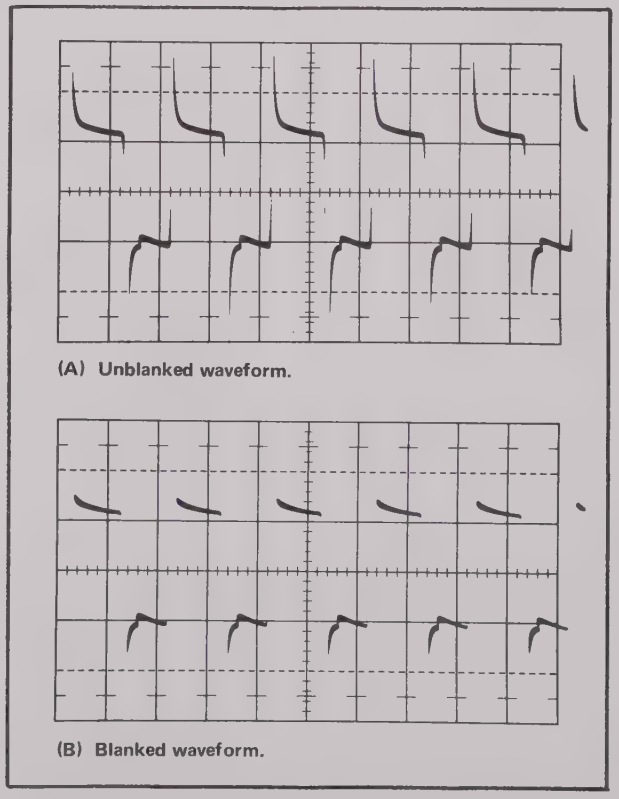
g. Set the CRT CATHODE SELECTOR switch (rear top of Oscilloscope) to DUAL TRACE CHOPPED BLANKING.

h. CHECK—The intensity of the chopped transients (rising and falling portions of the display) should become greatly attenuated. See Fig. 5-9B.

i. Change the CRT CATHODE SELECTOR switch to EXTERNAL CRT CATHODE.

j. Switch the Calibration Fixture Test Function switch to Low Load, and the Oscilloscope TIME/CM to 1 mSEC.

k. If a Calibration Procedure is being performed, proceed with step 15. If a Performance Check is being done, omit steps 15 through 22 and proceed with step 23.



(A) Unblanked waveform.

(B) Blanked waveform.

Fig. 5-9. Chopped-blanking waveforms; step 14.

15. (Calibration Procedure only) Adjust Time Base A Trigger Level Centering (TRIG LEVEL CENTERING, R39)

a. The control settings given in Table 5-1 apply. Equipment setup appears in Fig. 5-3.

b. Set the Oscilloscope AMPLITUDE CALIBRATOR to .2 VOLTS.

c. Set the Time Base A Controls as follows: TRIGGERING SLOPE to +EXT, STABILITY control fully clockwise.

d. Connect a BNC T (item 18) to the Oscilloscope CAL. OUT connector. Then connect a 50 Ω coaxial cable from the T to the Time Base A TRIGGER INPUT connector, and a second coaxial cable from the T to the Calibration Fixture Ext Input connector.

e. Set the Calibration Fixture Variable control fully clockwise.

f. Ground the R19-R20 junction (Fig. 5-10) with a short jumper lead equipped with small alligator clips (item 15).

g. Turn TRIG LEVEL CENTERING R39 (Fig. 5-10) fully clockwise.

h. Turn the STABILITY control counterclockwise until the display disappears from the CRT; then turn it two or three degrees further counterclockwise. Leave the STABILITY control at this position through step 17.

i. ADJUST—Turn the TRIG LEVEL CENTERING control counterclockwise until a stable display appears on the CRT.

j. Set the TRIGGER SLOPE switch to —EXT; if necessary, readjust the TRIG LEVEL CENTERING control slightly counterclockwise to obtain a stable display.

k. Change the TRIGGER SLOPE switch back and forth between + and —EXT, and if necessary readjust the TRIGGER LEVEL CENTERING control slightly to obtain a stable display in the + and —EXT settings of the TRIGGER SLOPE switch.

l. Set the TRIGGER SLOPE switch to +INT and check that a stable display remains.

m. INTERACTION—A Internal Trigger DC Level, step 16, A Trigger Sensitivity, step 17.

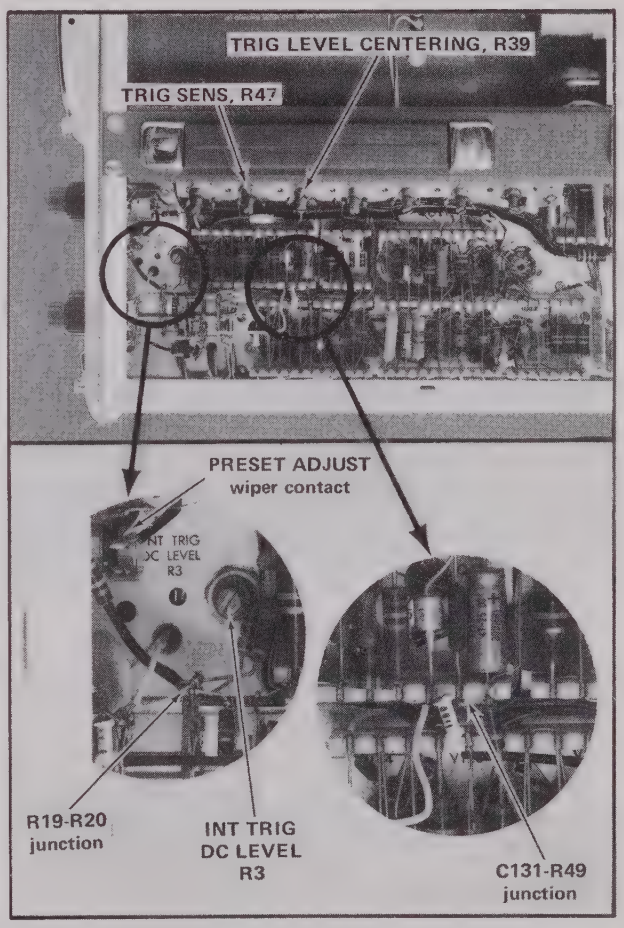


Fig. 5-10. Top view, showing test point and adjustment locations; steps 15 through 18.

16. (Calibration Procedure only) Adjust A Internal Trigger DC Level; Check/Adjust A TRIGGERING LEVEL Knob Position (INT TRIG DC LEVEL, R3)

a. Equipment setup is continued from step 15.

b. Set the Oscilloscope AMPLITUDE CALIBRATOR switch to 1 volt.

c. Using the Calibration Fixture Variable control, adjust the display amplitude to 6 mm.

d. Center the display vertically, and turn the Time Base A TRIGGERING MODE switch to DC.

e. ADJUST—INT TRIG DC LEVEL R3 (Fig. 5-10) for a stable display while switching the TRIGGER SLOPE switch back and forth between + and —INT. It may be necessary to repeat the TRIG LEVEL CENTERING control adjustment (step 15) to obtain a stable display.

f. Remove the grounding jumper from the R19-R20 junction.

g. With the 6 mm display at graticule center, adjust the Time Base A TRIGGERING LEVEL control as necessary to obtain a triggered display.

h. CHECK—The white dot on the TRIGGERING LEVEL control knob should point to within a few degrees of 0. If it does not, loosen the knob setscrew with a 1/16 inch hex key wrench. Move the knob to 0. Check that a triggered display remains and then tighten the setscrew.

i. Turn the AMPLITUDE CALIBRATOR off. Disconnect the cable from the Oscilloscope TRIGGER INPUT connector.

17. (Calibration Procedure only) Check/Adjust A Trigger Sensitivity (TRIG SENS, R47)

a. The control settings given in Table 5-1 apply. Equipment setup appears in Fig. 5-3.

b. Set the Time Base A TRIGGERING MODE switch to AUTO and the TRIGGER SLOPE switch to +EXT.

c. Set the Test Oscilloscope as follows: Time/Div 5 ms, Volts/Div 0.5 V, 10X probe (item 11) attached to the vertical input.

d. Connect the Test Oscilloscope 10X probe to the collector of Q45 at the junction of C131 and R49 (Fig. 5-10).

e. Connect a 6 inch BNC to banana patch cord (item 14) from the Time Base A TRIGGER INPUT connector to ground.

f. Set the Test Oscilloscope triggering controls for a stable display on the Test Oscilloscope.

g. CHECK—One cycle of the display on the Test Oscilloscope should occupy 5 cm of the sweep.

h. ADJUST—TRIG SENS R47 (Fig. 5-10) so that one cycle of display on the Test Oscilloscope occupies 5 cm of the sweep.

i. Disconnect the Test Oscilloscope probe from the test point.

18. (Calibration Procedure only) Adjust Time Base A Preset (PRESET ADJUST, R111)

a. The control settings given in Table 5-1 apply except that the TRIGGERING MODE switch is at AUTO and a BNC to banana-plug patch cord is connected between the A TRIGGER INPUT and ground. Basic setup of equipment appears in Fig. 5-3.

b. Set the Time Base A TRIGGER SLOPE switch to +LINE, and STABILITY control fully counterclockwise to the PRESET detent, and the A TIME/CM to .1 mSEC.

c. Set the DC Voltmeter for —70 volt measurement. Connect the Voltmeter between ground and the wiper arm (center lug) of the PRESET ADJUST potentiometer (R111, Fig. 5-10).

d. Turn the PRESET ADJUST control (front panel) fully counterclockwise. Then turn it clockwise until a trace appears on the CRT. Note the voltage reading on the Voltmeter. Continue turning the PRESET ADJUST control clockwise until the trace brightens. Note the voltage reading on the Voltmeter. (Meter reading difference should equal or exceed 10 volts).

e. ADJUST—PRESET ADJUST for a voltage reading midway between the two previously noted meter readings.

f. Disconnect the Voltmeter and remove the grounding patch cord from the TRIGGER INPUT connector.

19. (Calibration Procedure only) Adjust B Trigger Level Centering (TRIG LEVEL CENTERING, R82)

a. The control settings given in Table 5-1 apply. Equipment setup appears in Fig. 5-3.

b. Set the HORIZONTAL DISPLAY switch to B. Adjust the INTENSITY control as necessary to obtain a visible display.

c. Set the Oscilloscope Time Base B TRIGGERING MODE switch to + EXT and the AMPLITUDE CALIBRATOR switch to .1 VOLTS.

d. With the BNC T connected to the Oscilloscope CAL OUT jack, connect a 50 Ω coaxial cable from the T to the Ext Input connector on the Calibration Fixture. Connect a second 50 Ω coaxial cable from the T to the Time Base B TRIGGER INPUT connector.

e. Check that the Calibration Fixture VARIABLE control is fully clockwise, and that a free-running display is present.

f. Turn the Oscilloscope off.

g. Ground the R69-R70 junction at SW60A (Fig. 5-11), using a short jumper equipped with alligator clips.

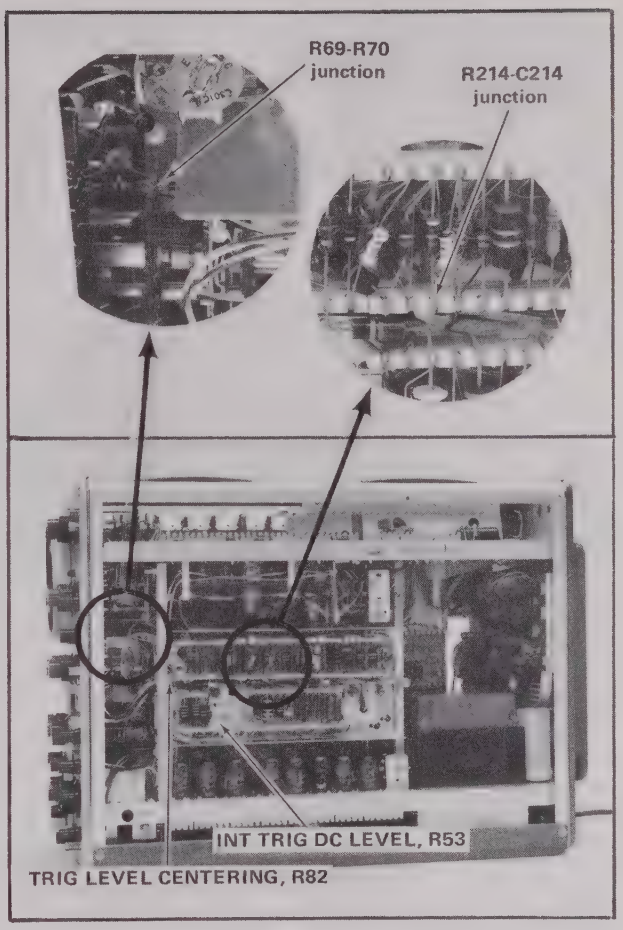


Fig. 5-11. Test points and adjustment locations, steps 19, 20 and 21.

h. Turn the Oscilloscope on and wait approximately three minutes before continuing.

i. Turn TRIG LEVEL CENTERING R82 (Fig. 5-11) fully clockwise.

j. Turn the B STABILITY control counterclockwise until the trace just disappears from the CRT. Then turn it two or three degrees further counterclockwise. Leave it in this position through step 20.

k. ADJUST—TRIG LEVEL CENTERING R82 (Fig. 5-11) counterclockwise until a stable display appears on the CRT. Turn it further counterclockwise until the display disappears. Then reset the adjustment midway between the two points.

l. Change the B TRIGGER SLOPE switch to – EXT and readjust the TRIG LEVEL CENTERING control if necessary to obtain a stable display.

m. CHECK—Switch the B TRIGGER SLOPE switch back and forth between + and –EXT; refine the TRIG LEVEL CENTERING adjustment as necessary to obtain a stable display in both positions of the B TRIGGER SLOPE switch.

n. Switch the B TRIGGERING SOURCE switch to +INT. Adjust the Calibration Fixture Variable control as necessary to obtain a 2 mm display. (Increase the AMPLITUDE CALIBRATOR signal to .2 V if insufficient display appears with a .1 V signal.)

NOTE

A 0.1 V signal is used to obtain optimum EXT triggering adjustment in this step. If proper triggering cannot be obtained, apply a 0.2 V signal, as specified for minimum external triggering signal amplitude in Section 1.

o. CHECK—A stable display should appear in both + and –INT positions of the B TRIGGER SLOPE switch.

p. INTERACTION—B Internal Trigger DC Level, step 20.

20. (Calibration Procedure only) Adjust B Internal Trigger DC Level (INT TRIG DC LEVEL, R53); Check/Adjust B TRIGGERING LEVEL Knob Position

a. Equipment setup is continued from step 19.

b. Set the AMPLITUDE CALIBRATOR to 1 VOLT.

c. Using the Calibration Fixture Variable control, reduce the display amplitude to 6 mm.

d. Position the display equally above and below the graticule center.

e. Set the B TRIGGER MODE switch to DC.

f. CHECK—A stable display should exist on the CRT.

g. ADJUST—INT TRIG DC LEVEL R53 (Fig. 5-10) as necessary to obtain a stable display.

h. Change the B TRIGGER SLOPE switch to –INT.

i. CHECK—A stable display should remain on the CRT. Adjust the INT TRIG DC LEVEL control as necessary to obtain a stable display.

j. CHECK—Change the B TRIGGER SLOPE switch back and forth between + and –INT and readjust the INT TRIG DC LEVEL control as necessary to obtain a stable display in both positions of the B TRIGGER SLOPE switch. (If a stable display cannot be obtained, adjust the TRIG LEVEL CENTERING control slightly as necessary to obtain a stable display. If the TRIG LEVEL CENTERING is adjusted, then recheck that the Oscilloscope will trigger in AC + and –INT on a 2 mm display, and in AC + and –EXT on an externally applied 0.2 V signal.)

k. Set the B TRIGGERING SLOPE switch to +INT.

l. Turn the Oscilloscope off. Then remove the grounding jumper from the R69-R70 junction and turn the Oscilloscope on. Wait three minutes before continuing.

m. Adjust the B TRIGGERING LEVEL control as necessary to obtain stable triggering.

n. CHECK/ADJUST—The white dot on the TRIGGERING LEVEL knob should point to within a few degrees of 0. If it doesn't, loosen the knob with a 1/16 inch hex key wrench and move it to 0 position. Check that a stable display remains on the CRT and tighten the knob's setscrew.

o. Disconnect the 50 Ω coaxial cables and the BNC T from the Oscilloscope and Calibration Fixture.

21. (Calibration Procedure only) Adjust Time Base B Preset (PRESET ADJUST, R211)

a. The control settings given in Table 5-1 apply, except that the HORIZONTAL DISPLAY switch is at B.

b. Set the B TRIGGERING MODE switch to AUTO, the B TRIGGER SLOPE switch to +LINE.

c. Set the B STABILITY control fully counterclockwise to the PRESET position.

d. Set the B TIME/CM switch to .1 mSEC.

e. Set the DC Voltmeter for 0 to −70 volt range and connect it between ground and the R214-C214 junction. See Fig. 5-11.

f. CHECK—Turn the B PRESET ADJUST R211 (front panel) control fully counterclockwise; then turn it clockwise until a trace appears on the CRT. Note the reading on the Voltmeter. Continue turning the PRESET ADJUST clockwise until the trace brightens. Note the voltage reading on the Voltmeter. (Meter reading difference should be equal to or exceed 10 volts.)

g. ADJUST—B PRESET ADJUST R211 for a voltage reading midway between the two previously noted meter readings.

h. Disconnect the Voltmeter leads.

22. (Calibration Procedure only) Adjust Lock-Out Level (LOCK-OUT LEVEL ADJUST, R125)

a. The control settings given in Table 5-1 apply. Equipment setup appears in Fig. 5-14.

b. Set the B STABILITY control fully clockwise, B TRIGGER SLOPE switch to +INT, and B TRIGGERING MODE switch to AC.

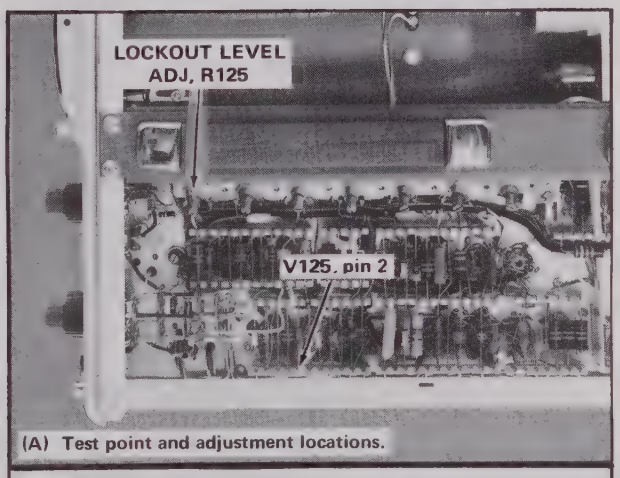
c. Set the A STABILITY control fully clockwise, A TRIGGER SLOPE switch to +INT, and A TRIGGERING MODE switch to AC.

d. Set the HORIZONTAL DISPLAY switch to 'A' DLY'D BY 'B'.

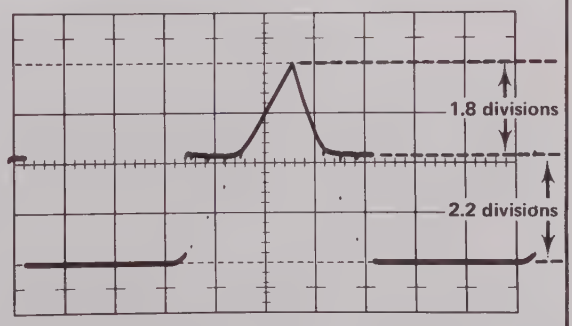
e. Check that the A TIME/CM switch is at .1 mSEC and set the B TIME/CM switch to 5 μSEC.

f. Turn the A STABILITY control counterclockwise to the point where the sweep just barely runs.

g. Set the Test Oscilloscope as follows:



(A) Test point and adjustment locations.



(B) Reference waveform. 5 V/division vertical sensitivity; .2 ms/division sweep rate.

Fig. 5-12. Lock-out level test point location, adjustment location, and reference waveform for step 22.

Time/div	.2 mSEC
Input Coupling	AC
Input Slope	INT–
Volts/div	.5
Triggering Mode	Auto

h. Connect a 10X probe from the Test Oscilloscope to V125—Pin 2. See Fig. 5-12A.

i. Adjust the Test Oscilloscope Variable Volts/div control for a display amplitude of 4 divisions; adjust its triggering controls for a stable display.

j. CHECK—The square wave portion of the display should have an amplitude of 2.2 divisions and the sawtooth portion should have an amplitude of 1.8 divisions. See Fig. 5-12B.

k. ADJUST—LOCKOUT LEVEL ADJ R125 (Fig. 5-12A) so that the square wave portion of the waveform has an amplitude of 2.2 divisions and the sawtooth portion has an amplitude of 1.8 divisions, as in Fig. 5-12B.

l. Return the Test Oscilloscope Variable Volts/div to Calibrated.

m. CHECK—Amplitude of the square wave portion of the waveform should be at least 9 volts.

n. Disconnect the 10X probe from V125—Pin 2.

NOTES

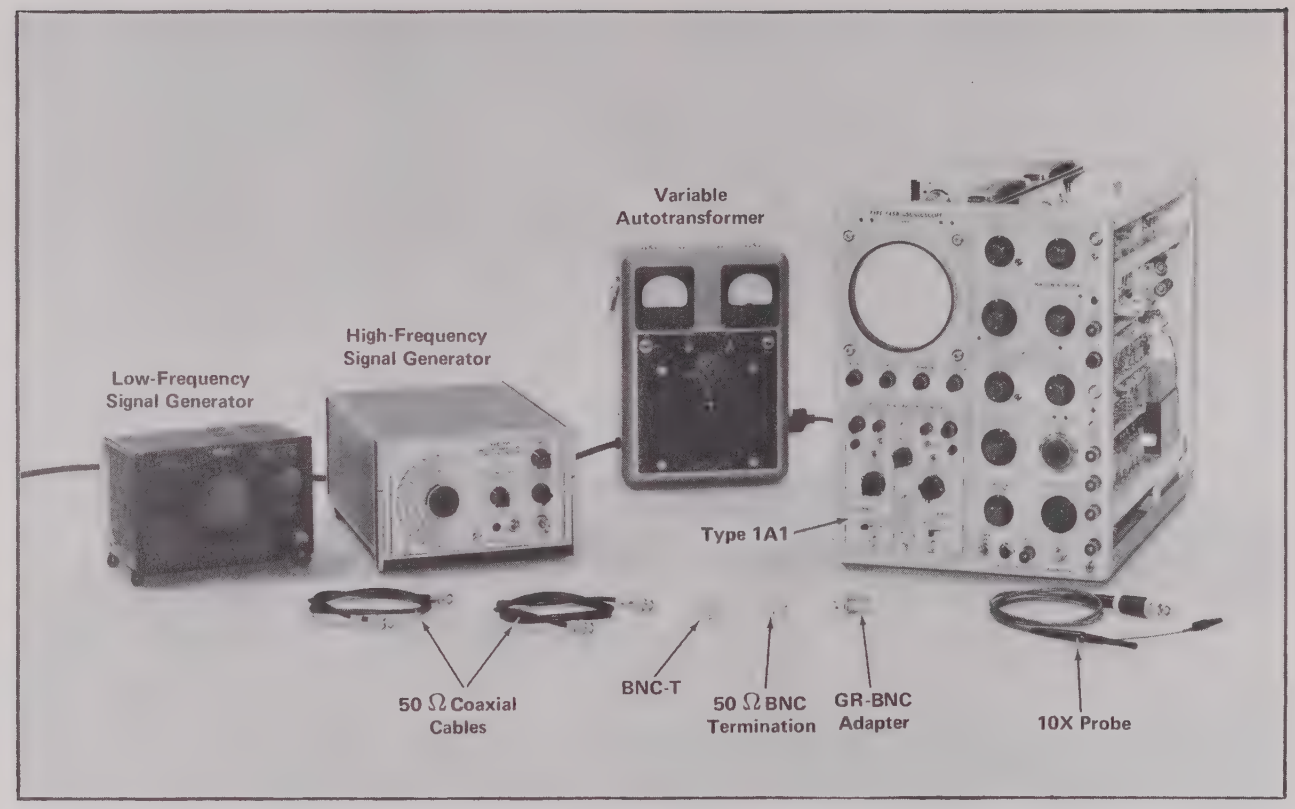


Fig. 5-13. Basic setup of equipment for steps 23 through 26.

TABLE 5-7

Basic Setup for Steps 23 Through 39.

Oscilloscope	
CRT Controls	
FOCUS and ASTIGMATISM	Well focused display
INTENSITY	Adjusted for nominal brightness
HORIZONTAL DISPLAY	B
5X MAGNIFIER	OFF
Time Base A Controls	
TIME/CM	1 mSEC
VARIABLE	CALIBRATED
STABILITY	PRESET
TRIGGERING LEVEL	0
TRIGGER SLOPE	+INT
TRIGGERING MODE	AC
Time Base B Controls	
TIME/CM	1 mSEC
LENGTH	10 CM
STABILITY	PRESET
TRIGGERING LEVEL	0
TRIGGER SLOPE	+INT
TRIGGERING MODE	AC
DELAY-TIME MULTIPLIER 1-10	1.00
AMPLITUDE CALIBRATOR	OFF
HORIZONTAL POSITION	Midrange or centered display

Vertical Plug-In Unit (Type 1A1)	
Volts/cm	1
Input Selector	AC
Mode	Ch 1

23. Check Time Base A and B Low-frequency Triggering Sensitivity

REQUIREMENT: Refer to Section 1.

a. Control settings given in Table 5-7 apply. The basic setup of equipment appears in Fig. 5-13.

b. Turn the Oscilloscope off. Remove the Calibration Fixture and install the Type 1A1 Vertical Plug-in Unit (item 3)

c. Turn the Oscilloscope on and permit it to warm up for five minutes before performing the next CHECK.

d. Set the Oscilloscope and Plug-In controls as listed in Table 5-7.

e. Connect a BNC T to the Type 1A1 Channel 1 Input connector.

f. Connect a 42 inch coaxial cable from the Low Frequency Signal Generator (item 10) to the BNC T.

g. Connect a second 42 inch coaxial cable from the BNC T to the Oscilloscope Time Base B TRIGGER INPUT connector.

h. Set the Time Base B Time/Cm control to 2 mSEC.

i. CHECK—A triggered display should be obtainable under each setup given in Table 5-8. Adjust the STABILITY and TRIGGERING LEVEL as necessary.

24. Check Time Base A and B Triggering Response at Mid and High Frequency

REQUIREMENT: Refer to section 1.

a. Equipment setup is continued from step 23.

b. Disconnect the coaxial cable from the Low Frequency Signal Generator and connect it to the Output of the Type 191 Constant Amplitude Signal Generator (item 6), using a GR to BNC adapter (item 16).

c. Insert a 50 Ω BNC Termination (item 17) between the coaxial cable and the BNC connector at the Oscilloscope Trigger Input.

d. Set the Oscilloscope Time Base A TIME/CM to .1 μSEC.

e. CHECK—A triggered Time Base A display should be obtainable under each setup given in Table 5-9.

25. Check Time Base A Single Sweep Operation

REQUIREMENT: The READY lamp should light when the RESET button is pressed; the light should extinguish after a single sweep occurs.

a. Control settings given in Table 5-7 apply. Equipment setup appears in Fig. 5-13.

b. Set the Oscilloscope controls as follows:

HORIZONTAL DISPLAY	A
5X MAGNIFIER	OFF
Time Base A	
TRIGGERING MODE	AC
TRIGGER SLOPE	INT+
TIME/CM	.5 mSEC
AMPLITUDE CALIBRATOR	1 V
VOLTS/CM	2 V

c. Connect a 50 Ω coaxial cable from the Oscilloscope CAL OUT jack to the Oscilloscope Vertical Input connector.

d. Adjust the Time Base A Triggering controls as necessary to obtain a stable triggered square-wave display.

e. Set the HORIZONTAL DISPLAY Control to 'A' SINGLE SWEEP and then remove the coaxial cable from the Vertical Input connector.

f. CHECK—Single sweep reset operation. Depress the RESET button one time and note that the READY lamp illuminates and remains on.

g. CHECK—Single sweep operation. A single sweep should occur immediately after the coaxial cable is re-connected to the Vertical Input connector; the READY lmap should extinguish and remains off.
lamp should extinguish and remains off.

TABLE 5-8

Low-Frequency Triggering Sensitivity Check

HORIZONTAL DISPLAY	Signal Generator Frequency	TRIGGERING MODE	TRIGGER SLOPE	Triggering Signal Amplitude
B	300 Hz (6 cycles) (in 10 div)	AUTO	INT +	5 mm
			INT –	5 mm
			EXT +	0.5 V (5 cm at 0.1 V/CM)
			EXT –	0.5 V
		AC	EXT –	0.2 V (2 cm at 0.1 V/CM)
		DC	EXT –	0.2 V
		AC	INT +	2 mm
		DC	INT +	6 mm (displayed within 1 cm of graticule center)
Move the coaxial cable from the B TRIGGER INPUT to the A TRIGGER INPUT; switch the HORIZONTAL DISPLAY to A, Time Base A TIME/CM to 5 mSEC/CM.				
A	150 Hz (7.5 cycles) (in 10 div)	AUTO	INT +	5 mm
			INT –	5 mm
			EXT +	0.5 V (5 cm at 0.1 V/CM)
			EXT –	0.5 V
		AC	EXT –	0.2 V (2 cm at 0.1 V/CM)
		DC	EXT –	0.2 V
		AC	INT +	2 mm
		DC	INT +	6 mm (displayed within 1 cm of graticule center)
Switch the Time Base A TIME/CM to 20 μSEC.				
A	30 kHz (6 cycles) (in 10 div)	AC LF REJECT	INT +	2 mm
			EXT +	0.2 V (2 cm at 0.1 V/CM)

h. CHECK-The READY lamp should illuminate momentarily and a single sweep should occur each time the RESET button is depressed.

i. Disconnect the coaxial cable from the Oscilloscope and set the HORIZONTAL DISPLAY switch to A.

26. Check Line Triggering

REQUIREMENT: Stable triggering with correct polarity should be obtained when displaying a line-frequency signal obtained from the Oscilloscope operating power source.

a. Control settings given in Table 5-7 apply. Connect the BNC connector of a 10X probe to the Vertical Input connector; set the Vertical Input Coupling switch to AC.

b. Calibration Procedure only:

(1) Set the VOLTS/CM switch to 0.5 V.

(2) Connect the probe tip to the terminal on the Scale Illumination lamp on the inside-right-top of the Oscilloscope front panel.

TABLE 5-9

Mid and High-Frequency Triggering Sensitivity Check

Signal Generator Frequency	TRIGGER SLOPE	TRIGGERING MODE	Triggering Signal Amplitude
10 MHz	EXT +	AC LF REJECT	0.2 V
		AC	0.2 V
		DC	0.2 V
	INT +	DC	6 mm (displayed within 1 cm of graticule center)
		AC	2 mm
		AC LF REJECT	2 mm
30 MHz	INT +	AC LF REJECT	1 cm
		AC	1 cm
	EXT +	AC	1 V
		AC LF REJECT	1 V
		DC	1 V
Move the 50 Ω termination and coaxial cable from the A TRIGGER INPUT to the B TRIGGER INPUT; change the HORIZONTAL DISPLAY to B; turn the 5X MAGNIFIER on; switch the B TIME/CM to 2 μs; increase the INTENSITY as necessary.			
5 MHz	INT +	AC	2 mm
		DC	6 mm (displayed within 1 cm of graticule center)
	EXT +	DC	0.2 V
		AC	0.2 V
10 MHz	EXT +	AC	1.0 V
		DC	1.0 V
	INT +	AC	1 cm
Remove the Cables, termination, and BNC T from the Equipment.			

(3) Turn the SCALE ILLUM control fully clockwise.

c. Performance Check only:

(1) Set the VOLTS/CM switch to 10 V/cm.

(2) Connect the 10X probe tip to the line voltage supply.

d. Set the Time Base A TIME/CM switch to 5 mSEC, and the TRIGGER SLOPE switch to + LINE.

e. CHECK—Adjust the Time Base A TRIGGERING LEVEL and STABILITY controls as necessary to have the trace start approximately at the middle of the positive-going slope of a cycle of the waveform.

f. CHECK—Switch the TRIGGER Slope Switch to — LINE and check that the TRIGGERING LEVEL and STABILITY controls can cause the trace to start at the approximate middle of the negative-going slope of the input waveform.

NOTE

Triggering in a portion of the TRIGGERING LEVEL range may cause an opposite slope to appear at the start of the trace.

g. Reset the Oscilloscope controls as follows:

Time Base A TRIGGERING SLOPE	INT +
HORIZONTAL DISPLAY	B
Time Base B TIME/CM	5 mSEC
TRIGGER SLOPE	+ LINE

h. CHECK—Adjust the Time Base B TRIGGERING LEVEL and STABILITY controls as necessary to obtain a stable display, with the trace starting at the approximate middle of the positive-going slope of a cycle of the waveform.

i. CHECK—Switch the Time Base B Trigger Slope Switch to — LINE and check that the TRIGGERING LEVEL and STABILITY controls can cause the trace to start at the approximate middle of the negative-going slope of the waveform.

j. Set the Time Base B TRIGGER SLOPE switch to INT + and the B Time/cm to 1 mSEC.

k. Disconnect the 10X probe tip from the AC voltage. Remove the probe connector from the Vertical Input connector.

NOTES

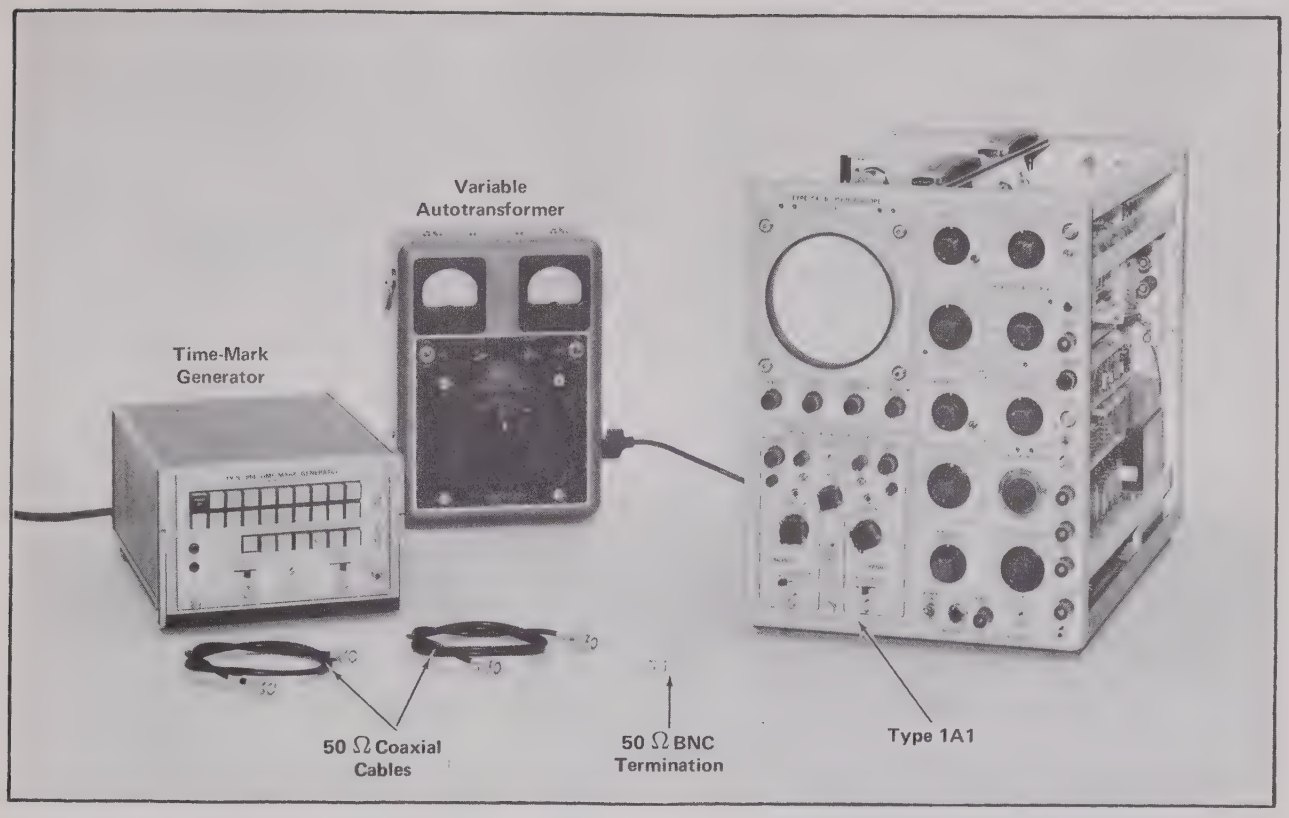


Fig. 5-14. Basic setup of equipment for steps 27 through 39.

27. Check/Adjust 5X Magnifier Gain (MAG GAIN, R375)

REQUIREMENT: 5X MAGNIFIER sweep timing should be equal to real time ±5%.

a. Control settings given in Table 5-7 apply. Equipment setup is shown in Fig. 5-14.

b. Set the Type 184 Time-Mark Generator (item 5) to produce .1 mSEC time markers.

c. Connect a 50 Ω BNC termination to the Vertical Plug-In CH 1 Input connector. Connect a 42 inch coaxial cable from the 50 Ω termination to the Time-Mark Generator Marker Output connector.

d. Turn the Oscilloscope 5X MAGNIFIER on.

e. CHECK—5X MAGNIFIER lamp should be on.

f. Adjust the B TRIGGERING LEVEL control for a stable display of 2 markers per cm.

g. Position the display to place a marker exactly on the second vertical graticule line from the left. See Fig. 5-15A.

h. CHECK—For a display of exactly two time-markers/cm between the second and tenth vertical graticule lines. With a marker aligned to the second line, the appropriate marker should be within ±4 mm of the tenth vertical line. See Fig. 5-15B.

NOTE

All timing adjustment measurements should be made between the second and tenth vertical lines (middle 8 centimeters).

i. (Calibration Procedure only) ADJUST—MAG GAIN R375 (Fig. 5-15B) for exactly two time-marks/cm between the second and tenth vertical graticule lines. Align markers with the 2nd and 10th vertical graticule lines respectively to provide optimum measurement accuracy. Fig. 5-15 shows the display when MAG GAIN control is properly adjusted.

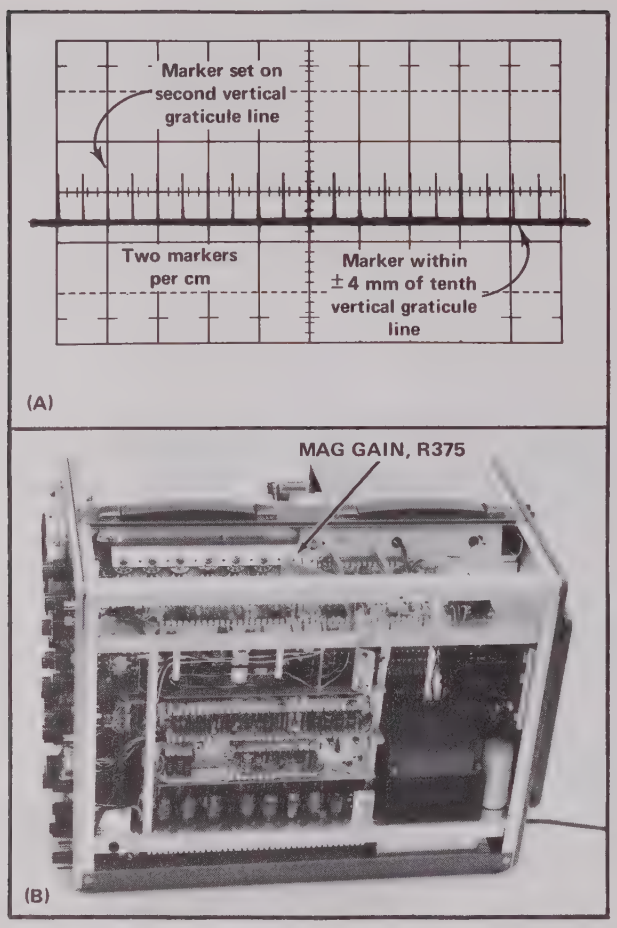

Marker set on second vertical graticule line
Two markers per cm
Marker within ±4 mm of tenth vertical graticule line
(A)
MAG GAIN, R375
(B)

Fig. 5-15. 5X magnifier gain waveform and location of adjustment, step 27. Sweep rate 1 mSEC/CM.

INTERACTION — Affects all timing of A and B sweeps, steps 28 through 38.

28. Check/Adjust Sweep Registration (NORM/MAG REGIS, R358)

REQUIREMENT—The portion of the display that is aligned with the center vertical graticule line must not shift more than 0.5 cm when the 5X MAGNIFIER is switched ON or OFF.

a. The Control settings given in Table 5-7 apply except that the 5X MAGNIFIER is ON, and a triggered time-marker display exists on the CRT. Basic setup of equipment appears in Fig. 5-14.

b. Switch the Time-Mark Generator to 1 ms markers.

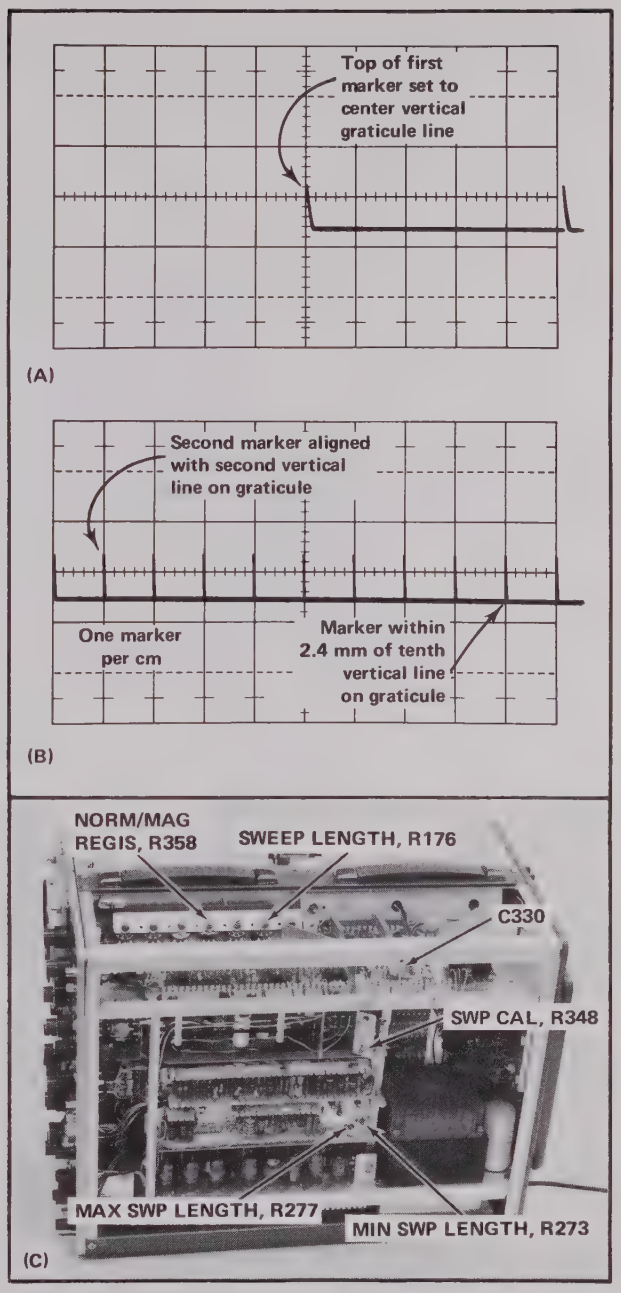

Top of first marker set to center vertical graticule line
(A)
Second marker aligned with second vertical line on graticule
One marker per cm
Marker within 2.4 mm of tenth vertical line on graticule
(B)
NORM/MAG REGIS, R358
SWEEP LENGTH, R176
C330
SWP CAL, R348
MAX SWP LENGTH, R277
MIN SWP LENGTH, R273
(C)

Fig. 5-16. (A) Sweep registration waveform, step 28. (B) Unmagnified slow sweep rate accuracy waveform, step 30. (C) Adjustment locations for steps 28 through 32.

c. With the HORIZONTAL POSITION controls, position the display to place the first marker directly behind the center vertical graticule line. See Fig. 5-16A.

d. Turn the 5X MAGNIFIER switch off.

e. CHECK—The first marker should remain within 0.5 cm of being aligned with the center graticule line.

f. Calibration Procedure only:

(1) ADJUST—NORM/MAG REGIS R358 (Fig. 5-16C) to place the first large time mark directly behind the center graticule line. See Fig. 5-21.

(2) Turn the B LENGTH control fully clockwise and repeat steps d through g until the sweep length is set correctly for minimum and maximum lengths.

g. Turn the 5X MAGNIFIER switch OFF.

29. Check/Adjust B Time Base Sweep Length (MAX SWP LENGTH, R277; MIN SWP LENGTH, R273)

REQUIREMENT—B LENGTH control should be variable from at least 10 cm to less than 4 cm.

a. Control Settings given in Table 5-7 apply. Basic setup of equipment appears in Fig. 5-14.

b. Check that the B LENGTH control is fully clockwise.

c. CHECK—For a sweep length of not less than 10 cm.

d. (Calibration Procedure only): ADJUST—MAX SWP LENGTH. R277 (Fig. 5-16C) for a sweep length of approximately 10.5 cm.

e. Turn the B LENGTH fully counterclockwise.

f. CHECK—For a sweep length of 4 cm or less.

g. Calibration Procedure only:

(1) ADJUST—MIN SWP LENGTH R273 (Fig. 5-16C) for a sweep length of 3.5 cm.

(2) Turn the 5X MAGNIFIER switch on and repeat steps c through e until the first time mark stays aligned with the center graticule line when the 5X Magnifier switch is turned OFF and ON.

h. Set the LENGTH control fully clockwise.

30. Check/Adjust B Time Base Unmagnified Slow Sweep Rate Accuracy (SWEEP CAL, R348)

REQUIREMENT—Unmagnified sweep timing should be equal to real time within ±3%.

a. Control settings given in Table 5-7 apply except that a triggered 1 ms time-marker display exists on the CRT. Basic setup of equipment appears in Fig. 5-14.

b. Position the display to align the second marker with the second vertical graticule line as in Fig. 5-16B.

c. CHECK—One large marker/cm should exist, with the marker at the tenth vertical line within 2.4 mm of the tenth vertical graticule line as in Fig. 5-16B.

d. (Calibration Procedure only) ADJUST—SWEEP CAL R348 (Fig. 5-16C) for one large marker/cm between the second and tenth vertical graticule lines as in Fig. 5-16B.

e. CHECK—B sweep displayed timing accuracy. Repeat steps b and c for each setup listed in Table 5-10.

f. (Calibration procedure only) Readjust SWEEP CAL as necessary to remain within allowable at all sweep rates.

g. INTERACTION—R348 controls all displayed A and B sweep timing. Check step 31 through 35, and step 38.

TABLE 5-10

B Sweep Displayed Timing Accuracy; Slow Rates

Time Mark Generator Output	B Time/ CM	Marker Set to Second Vertical Graticule Line	Markers/ CM	Tolerance at Tenth Vertical Line
1 mS	1 mSEC	2nd	1	
1 mS	2 mSEC	3rd	2	
5 mS	5 mSEC	2nd	1	
10 mS	10 mSEC	2nd	1	
10 mS	20 mSEC	3rd	2	±2.4 mm
50 mS	50 mSEC	2nd	1	
.1 S	.1 SEC	2nd	1	
.1 S	.2 SEC	3rd	2	
.5 S	.5 SEC	2nd	1	
1 S	1 SEC	2nd	1	

31. Check/Adjust Horizontal Amplifier Input Compensation (C330)

REQUIREMENT—The trace should start within 5 mm of the same position on the graticule when the TIME/CM switch is changed from .1 mSEC to 50 μSEC (5X MAGNIFIER on).

a. Control settings listed in Table 5-7 apply. Equipment setup is shown in Fig. 5-14.

b. Set the Type 184 Time-Mark Generator to produce 10 μS markers on the CRT.

c. Set the HORIZONTAL DISPLAY switch to A, the Time Base A TIME/CM switch to .1 mSEC and turn the 5X MAGNIFIER on. Adjust the Triggering controls and increase the INTENSITY as necessary for optimum viewing.

d. Adjust the Horizontal Position controls as necessary to align the sweep start with the center vertical graticule line.

e. Change the A TIME/CM switch to 50 μSEC.

f. CHECK—The sweep should start within ±5 mm of the center graticule line.

g. (Calibration Procedure only) ADJUST—C330 (Fig. 5-16C) to position the beginning of the sweep to the center graticule line.

h. Set the A TIME/CM switch to .1 mSEC and repeat steps d through g until the beginning of the sweep remains at the center graticule line when the A TIME/CM switch is changed from .1 mSEC to 50 μSEC.

i. Switch the Time Base A Time/CM to 1 mSEC.

j. Turn the 5X MAGNIFIER off and position the display to start at the left edge of the graticule.

k. INTERACTION—C330 affects displayed fast sweep timing Check steps 35 and 38.

32. Check/Adjust A Sweep Length (SWEEP LENGTH, R176)

REQUIREMENT: A sweep length at 1 ms/cm should be 10.5 cm ±3%.

a. Control settings given in Table 5-7 apply, except that the HORIZONTAL DISPLAY switch is at A. The basic setup of equipment appears in Fig. 5-14.

b. CHECK—For a sweep length of 10.5 cm ±3 mm.

c. (Calibration Procedure only) ADJUST—SWEEP LENGTH R176 (Fig. 5-16C) for a sweep length of 10.5 cm.

33. Check Time Base A VARIABLE TIME/CM

REQUIREMENT—With VARIABLE fully counterclockwise, time/cm should be at least 2.5 times that selected by the TIME/CM control. The UNCALIBRATED lamp must light when the control is not in the CALIBRATED detent.

a. Control settings given in Table 5-7 apply, except that the HORIZONTAL DISPLAY switch is at A. Basic setup of equipment appears in Fig. 5-14.

b. Set the Type 184 Time Mark Generator to produce 5 ms markers. Adjust the Time Base A Triggering controls as necessary to obtain a stable display.

c. CHECK—For a display of one time-mark every 5 cm, with the TIME BASE A TIME/CM at 1 mSEC.

d. Set the VARIABLE TIME/CM control fully counterclockwise.

e. CHECK—The UNCALIBRATED indicator should be illuminated.

f. CHECK—2 cm or less separation should exist between adjacent time marks.

g. Set the TIME/CM VARIABLE control fully clockwise to the CALIBRATED position.

h. CHECK—The UNCALIBRATED lamp should be extinguished.

34. CHECK/ADJUST A Time Base Unmagnified Slow Sweep Rate Accuracy (R160Z)

REQUIREMENT—Unmagnified sweep timing should be equal to real time within ±3%.

a. The control settings given in Table 5-7 apply except that the HORIZONTAL DISPLAY Switch is at A. A triggered time mark display exists on the CRT. The basic setup of equipment appears in Fig. 5-14.

b. Set the Type 184 Time-Mark Generator to produce 1 ms markers.

c. Adjust the A TRIGGERING LEVEL control for a stable display.

d. With the HORIZONTAL POSITION control, align the second time-mark with the second vertical graticule line as in Fig. 5-16B.

e. CHECK—With the second time mark set to the second vertical line, the tenth time mark should be within ±2.4 mm of the tenth vertical line. See Fig. 5-16B.

f. Calibration Procedure only:

(1) ADJUST—R160Z (Fig. 5-17) so that the tenth time marker is exactly aligned with the tenth vertical line when the second time marker is exactly aligned with the second vertical graticule line. A properly adjusted display is similar to Fig. 5-16B.

(2) Switch the B TIME/CM control to 1 mSEC.

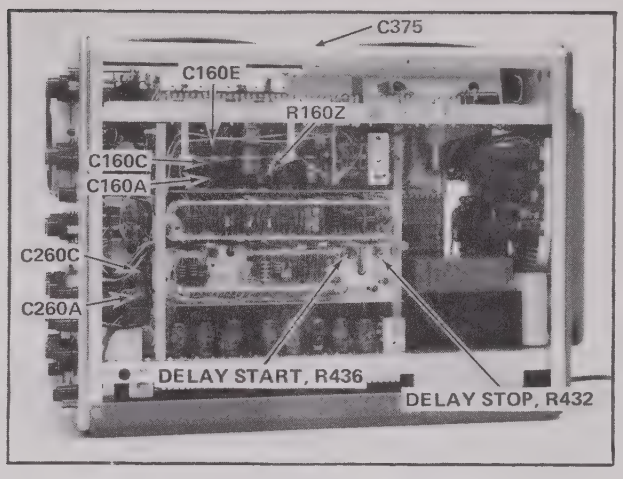


Fig. 5-17. Adjustment locations for steps 34 through 37.

(3) CHECK—A and B 1 ms/cm unmagnified timing against each other. Switch the HORIZONTAL DISPLAY switch back and forth between A and B positions while observing the display. The time between the second and tenth markers must compare within 0.5 mm on the two sweeps. Readjust the Horizontal Position Controls as necessary for optimum measurement. Refine the R160Z adjustment as necessary to correct the A sweep.

(4) Switch the HORIZ DISPLAY control to A.

g. Set the A TIME/CM switch and the Type 184 Time Mark Generator as in Table 5-11.

h. CHECK—A sweep timing accuracy under each setup given in Table 5-11. Reduce sweep intensity at slow rates to protect CRT phosphor.

i. INTERACTION—Affects A Time Base fast sweep rates. Check step 35.

35. Check/Adjust A Time Base Fast Sweep Rates (C160A, C375, C348, C160C, C160E)

REQUIREMENT—Display accuracy within ±3% of real time.

a. Control settings listed in Table 5-7 apply except that the HORIZONTAL DISPLAY switch is at A. A triggered time-mark display exists on the CRT. The basic setup of equipment appears in Fig. 5-14.

TABLE 5-11

A Sweep Timing Accuracy; Slow Rates

Time Mark Generator Output	A TIME/ CM	Marker Set To Second Vertical Graticule Line	Markers/ CM	Tolerance at tenth Vertical Line
.1 mS	.1 mSEC	2nd	1	
	.2 mSEC	3rd	2	
.5 mS	.5 mSEC	2nd	1	
1 mS	1 mSEC	2nd	1	
	2 mSEC	3rd	2	
5 mS	5 mSEC	2nd	1	±2.4 mm
10 mS	10 mSEC	2nd	1	
	20 mSEC	3rd	2	
50 mS	50 mSEC	2nd	1	
.1 S	.1 SEC	2nd	1	
	.2 SEC	3rd	2	
.5 S	.5 SEC	2nd	1	
1 S	1 SEC	2nd	1	
	2 SEC	3rd	2	
5 S	5 SEC	2nd	1	

b. Connect a 50 Ω coaxial cable from the Trigger Output connector on the Type 184 to the Time Base A TRIGGER INPUT connector on the Oscilloscope.

c. Set the Oscilloscope Time Base A TRIGGER SLOPE switch to + EXT.

d. CHECK—Time Base A fast sweep rates under each setup given in Table 5-12. Adjust the Oscilloscope TRIGGERING LEVEL control as necessary to obtain a stable display under each setup. The Vertical Plug-In Unit sensitivity can be increased and the baseline moved to below the viewing area for more convenient measurement as in Fig. 5-18.

e. (Calibration Procedure only) ADJUST—Time Base A fast sweep rates in the sequence given in Table 5-12. Adjustment locations are shown in Fig. 5-17.

f. Disconnect the coaxial cable from between the TRIGGER INPUT jack and the Time Mark Generator Trigger Output jack.

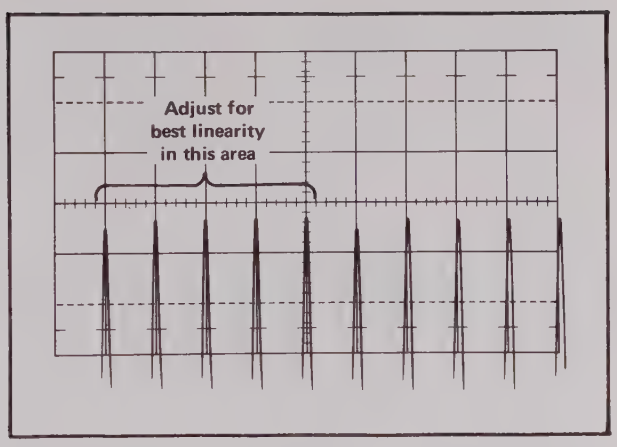


Fig. 5-18. .1 μSEC/CM linearity adjustment waveform, step 35. (The first marker is not visible because of fast rate of markers.)

36. Check/Adjust Basic Delay Accuracy (DELAY START R436, DELAY STOP R432)

REQUIREMENT—Actual delay should be within 1% of delay indicated by dial setting.

a. Control settings listed in Table 5-7 apply, except that time marks are being applied to the vertical input connector. The basic setup of equipment appears in Fig. 5-14.

b. Set the Type 184 Time Mark Generator to produce 1 ms time marks.

c. Set the A TIME/CM switch to .1 μs, the A TRIGGERING LEVEL and STABILITY controls fully clockwise, and the A TRIGGER SLOPE switch to + INT.

d. Set the HORIZONTAL DISPLAY switch to 'B' INTENSIFIED BY 'A'.

e. Set the B TIME/CM switch to 1 ms and adjust the B TRIGGERING LEVEL and STABILITY controls for a stable display, adjusting the Vertical Position and CRT INTENSITY as necessary to view the display.

f. Adjust the horizontal position controls so that the 2nd marker is aligned with the 2nd vertical graticule line from the left.

g. Set the DELAY-TIME MULTIPLIER to 9.00.

h. Adjust the INTENSITY as necessary to identify the small intensified portion of sweep appearing near the 10th vertical graticule-line.

i. Readjust the DELAY-TIME MULTIPLIER setting as necessary to intensity the extreme top of the marker appearing at the 10th vertical graticule line, as in Fig. 5-19A.

j. CHECK—DELAY STOP adjustment accuracy. Dial should read 9.00 ± .11

k. Set the DELAY-TIME MULTIPLIER dial for a reading of 1.00. Refine the adjustment so that the top of the 2nd marker is intensified.

l. Check DELAY START adjustment accuracy. The DELAY TIME dial should read 1.00 ± .03

m. Calibration Procedure only:

(1) Set the TIME BASE A TIME/CM to 10 μs.

(2) Set the DELAY-TIME MULTIPLIER dial accurately on 1.00.

(3) Adjust DELAY START R436 (Fig. 5-17) as necessary to intensify the marker appearing at the 2nd vertical graticule line, as in Fig. 5-19B.

(4) Set DELAY-TIME MULTIPLIER dial accurately on 9.00.

(5) Adjust DELAY STOP R432 (Fig. 5-17) as necessary to intensity the marker appearing at the 10th vertical graticule line.

(6) Set DELAY-TIME MULTIPLIER dial accurately on 1.00.

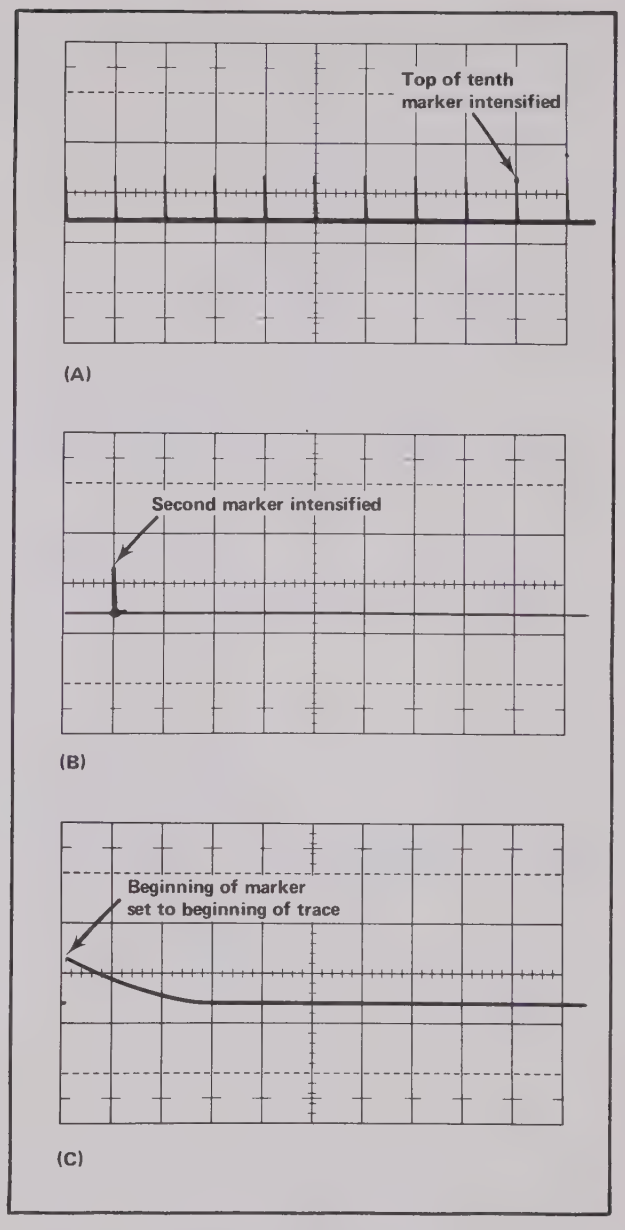


Fig. 5-19. Delay accuracy waveforms. (A) Step 36-i; (B) Step 36-m-(3); (C) Step 36-m-(9).

(7) If necessary, readjust DELAY START to intensify the 2nd marker.

(8) Switch HORIZONTAL DISPLAY to 'A' DELAY BY 'B'.

(9) Adjust DELAY START to position the start of the displayed marker at the start of the sweep, as in Fig. 5-19C.

(10) Set DELAY-TIME MULTIPLIER dial accurately to 9.00. A marker should appear on the CRT. If it does not, momentarily switch to 'B' INTENSIFIED BY 'A'. Adjust DELAY STOP R432 (Fig. 5-17) as necessary to intensify the marker appearing at the 10th vertical line, and then switch back to 'A' DELAYED BY 'B'.

(11) Adjust DELAY STOP R432 to position the start of the displayed marker to the start of the sweep as in Fig. 5-19C.

(12) Set the DELAY-TIME MULTIPLIER to 1.00 and repeat steps (9) thru (12) until the markers are adjusted as near by as possible to the start of the sweep under both setups.

n. Switch the HORIZONTAL DISPLAY control to 'B' INTENSIFIED BY 'A'. Set the DELAY-TIME MULTIPLIER to illuminate the top of a time mark indicated in the left column of Table 5-13. Switch to 'A' DLYD by 'B' and refine the DELAY TIME MULTIPLIER adjustment as necessary to place the start of the marker at the start of the sweep as in Fig. 5-19C. Record the dial reading. Repeat for each marker listed in Table 5-13.

o. Subtract the 2nd marker dial setting from the 10th marker dial setting. The difference should be 8.00 ±.12. Divide the results by 8.

p. CHECK—The incremental difference (difference between readings of adjacent markers) found in step m should be within .04 of the amount indicated by the solution of step o.

TABLE 5-12

A Sweep Fast Rate Check and Adjustment

Time Mark Generator		A TIME/CM	Marker/cm	Adjustment (Calibration Procedure only)	Check for
Trigger	Marker				
1 μS	.5 μS	.5 μSEC	1	C160A	8 cm ±2.4 mm separation between markers at 2nd and 10th vertical graticule lines
	.1 μS	.1 μSEC	1	C375 - Adjust for best linearity between 2nd and 6th graticule lines. See Fig. 5-18. C348 - Adjust for best timing between 2nd and 10th graticule lines. Recheck .5 μSEC position after adjustment.	
		.2 μSEC	2	Check. Compromise C160A, C348 & C375 adjustments if necessary to meet specification, keeping within tolerance at .1, .2 and .5 μs/cm Sweep rates.	
10 μS	1 μS	1 μSEC	1	C160C	
		2 μSEC	2	Check. Compromise C160C adjustment if necessary to meet specification, keeping within tolerance at 1, 2 and 5 μSEC/CM positions.	
	5 μS	5 μSEC	1		
	10 μS	10 μSEC	1	C160E	
		20 μSEC	2	Check. Compromise C160E adjustment if necessary to meet specification, keeping within tolerance at 10, 20 and 50 μSEC/CM positions.	
	50 μS	50 μSEC	1		

TABLE 5-13

DELAY TIME MULTIPLIER Incremental Accuracy

Marker	Dial Setting	Incremental Difference	Allowable
2nd			
3rd			
4th			
5th			
6th			1.00 ±.03
7th			
8th			
9th			
10th			

q. INTERACTION—Affects Time Base B fast sweep delay accuracy. Check step 37.

37. Check/Adjust Time Base B Fast Sweep Delay Accuracy (C260C, C260A); Check delay accuracy at all sweep rates

REQUIREMENT: Delay accuracy should be within 1% of indicated delay.

a. This step is dependent upon the accuracy of step 36.

b. Control settings listed in Table 5-7 apply. The basic setup of equipment appears in Fig. 5-14. 1 ms time marks are being applied to the Vertical Plug-In Unit.

c. Set the A TIME/CM to 2 μSEC, B TIME/CM to 50 μSEC and select 50 μS markers at the Type 184 Time Mark Generator.

d. Set the HORIZONTAL DISPLAY switch to 'B' INTENSIFIED BY 'A' and adjust the FOCUS, ASTIGMATISM, INTENSITY, TRIGGERING LEVEL and STABILITY controls for a sharp display of the vertical markers. Readjust the INTENSITY control as necessary to distinguish the intensified portion of the display.

e. Adjust the Horizontal Position controls as necessary to start the trace at the first vertical graticule line.

f. Set the DELAY TIME MULTIPLIER dial to 1.00. Refine the adjustment as necessary to intensify the marker appearing near the second vertical graticule line.

g. Switch the HORIZONTAL DISPLAY control to 'A' DLY'D BY 'B' and readjust the DELAY TIME MULTIPLIER dial as necessary to place the start of the marker at the left edge of the trace as in Fig. 5-19C. Record the DELAY TIME MULTIPLIER dial reading.

h. Switch the HORIZONTAL DISPLAY switch to 'B' INTENSIFIED BY 'A'. Then move the DELAY TIME MULTIPLIER dial to 9.00. Refine the dial setting as necessary to intensify the marker appearing near the tenth vertical graticule line.

i. Switch the HORIZONTAL DISPLAY control to 'A' DLY'D BY 'B' and readjust the DELAY TIME MULTIPLIER dial as necessary to place the start of the marker at the left edge of the trace as in Fig. 5-19C. Record the DELAY TIME MULTIPLIER dial reading.

j. CHECK—Difference between two dial readings should be 8.00 ±.12 dial divisions.

k. Calibration Procedure only:

(1) Set the dial exactly 8.00 divisions higher than the dial reading associated with the second marker.

(2) Adjust C260C (Fig. 5-17) as necessary to place the start of the marker at the start of the trace.

(3) Switch the HORIZONTAL DISPLAY to 'B' INTENSIFIED BY 'A' and check that the marker associated with the tenth vertical graticule line is being intensified.

(4) Change the DELAY TIME MULTIPLIER setting to approximately 1.00 and then readjust it as necessary to intensify the marker associated with the second vertical graticule line.

(5) Switch the HORIZONTAL DISPLAY switch to 'A' DELAYED BY 'B' and readjust the DELAY TIME MULTIPLIER to place the start of the marker at the start of the trace as in Fig. 5-19C. Record the DELAY TIME MULTIPLIER dial reading.

(6) Repeat step k until no further adjustment is necessary.

l. Switch the A TIME/CM to .2 μSEC, the B TIME/CM to 5 μSEC, and the Time Mark Generator output to 5 μs. Readjust the Time Base B Triggering controls if necessary to regain the trace.

m. Repeat steps d through k, this time adjusting C260A.

n. CHECK–Fast sweep timing accuracy at the remaining positions. Repeat steps d through j at each setup given in Table 5-14.

o. INTERACTION–Affects Time Base B fast sweep displayed accuracy. Check step 38.

38. Check Time Base B Unmagnified Fast Sweep Displayed Accuracy

REQUIREMENT: Display accuracy should be within 3% of real time.

a. Control settings listed in Table 5-7 apply, except that a time-mark display exists on the CRT. Basic setup of equipment appears in Fig. 5-14.

b. Switch the HORIZONTAL DISPLAY to B, and set the Oscilloscope and Time-Mark Generator controls to the positions listed in line 1 of Table 5-15.

c. Align the second marker with the second vertical graticule line.

d. CHECK–Displayed accuracy. The tenth marker should be within 2.4 mm of the tenth vertical line. Repeat the check for each switch position listed in Table 5-15.

TABLE 5-14

TIME BASE B Delay Accuracy Check

Time Mark Generator	TIME BASE B TIME/CM	TIME BASE A TIME/CM	Calibration Procedure Note
1 μS	2 μSEC	.2 μSEC	Controlled by the .5 μSEC/CM adjustment; refine as necessary to have all three within allowable limits.
10 μS	10 μSEC	.2 μSEC	
	20 μSEC	.2 μSEC	Controlled by the 50 μSEC/CM adjustment; refine as necessary to have all three within allowable limits.
.1 mS	.1 mSEC	2 μSEC	
	.2 mSEC	2 μSEC	Check
.5 mS	.5 mSEC	20 μSEC	
1 mS	1 mSEC	20 μSEC	
	2 mSEC	20 μSEC	
5 mS	5 mSEC	.2 mSEC	
10 mS	10 mSEC	.2 mSEC	
	20 mSEC	.2 mSEC	
50 mS	50 mSEC	2 mSEC	
1 S	.1 SEC	2 mSEC	
	.2 SEC	2 mSEC	
.5 S	.5 SEC	20 mSEC	
1 S	1 SEC	20 mSEC	

39. Check Dealy-Time Jitters

REQUIREMENT—Not more than 1/20,000 of available delay time (1/2000 of B Time/CM setting).

a. The control settings given in Table 5-7 apply, except that a triggered time-mark display exists on the CRT. Basic setup of equipment appears in Fig. 5-14.

b. Set the B TIME/CM switch to 1 mSEC, the A TIME/CM switch to 1 μSEC, the HORIZONTAL DISPLAY switch to 'B' INTENSIFIED BY 'A', and the Type 184 Time-Mark generator to produce 1 ms time-marks.

c. Adjust the Time Base B TRIGGERING LEVEL and STABILITY as necessary to obtain a triggered display.

d. Adjust the INTENSITY control as necessary to identify the intensified portion of the trace. Then set the DELAY-TIME MULTIPLIER dial to intensify the tenth time-mark as in Fig. 5-20A.

e. Set the HORIZONTAL DISPLAY switch to 'A' DLY'D by 'B' and adjust the DELAY-TIME MULTIPLIER dial to position the leading edge of the tenth time-mark near the center graticule line as in Fig. 5-20B.

f. CHECK—The horizontal jitter at the leading edge of the time-mark should not exceed 5 mm. See Fig. 5-20B.

g. Switch the HORIZONTAL DISPLAY to A and disconnect the termination and coaxial cable from the Vertical Plug-In Unit.

TABLE 5-15

B Sweep Fast Rate Displayed Accuracy Check

Time-Mark Generator	Time Base B TIME/CM	Marker Set To 2nd Vertical Line	Tolerance at 10th Vertical Line
.5 mS	.5 mSEC	2nd	
.1 mS	.2 mSEC	3rd	
	.1 mSEC	2nd	
50 μS	50 μSEC	2nd	
10 μS	20 μSEC	2nd	±2.4 mm
	10 μSEC	2nd	
5 μS	5 μSEC	2nd[1]	
1 μS	2 μSEC	3rd[1]	

[1] First marker may not be visible.

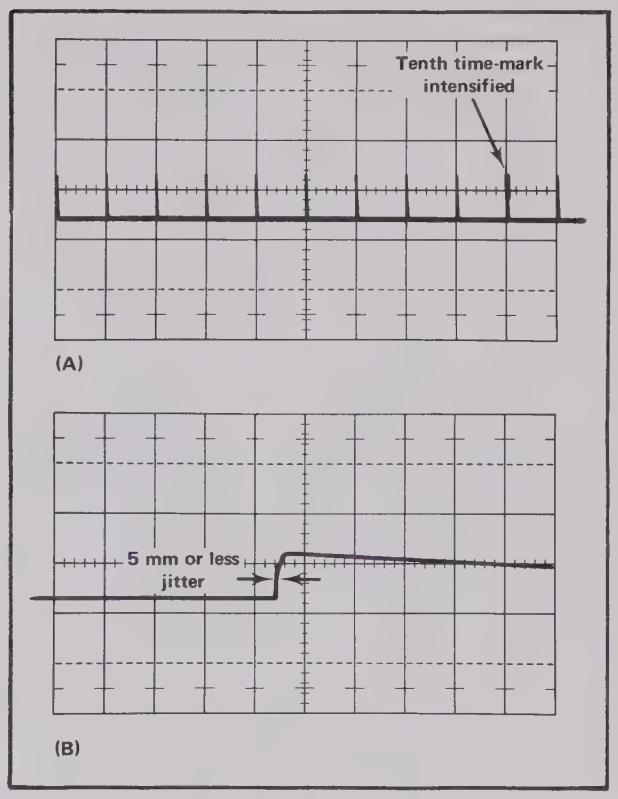


Fig. 5-20. Delay time jitter waveform, step 39.

TABLE 5-16

Basic Control Settings for Steps 40 through 43

Oscilloscope	
CRT Controls	
FOCUS and ASTIGMATISM	Well focused display
INTENSITY	Adjust for nominal brightness
HORIZONTAL DISPLAY	EXT X1
Time Base A Controls	
TIME/CM	.5 mSEC
STABILITY	PRESET
TRIGGER SLOPE	– EXT
TRIGGERING MODE	AC
HORIZONTAL POSITION	Midrange or centered display
Vertical Plug-In Unit (Type 1A1)	
Volts/cm	20
Input Selector	AC
Mode	CH 1
Position	Centered
Variable	Calibrated

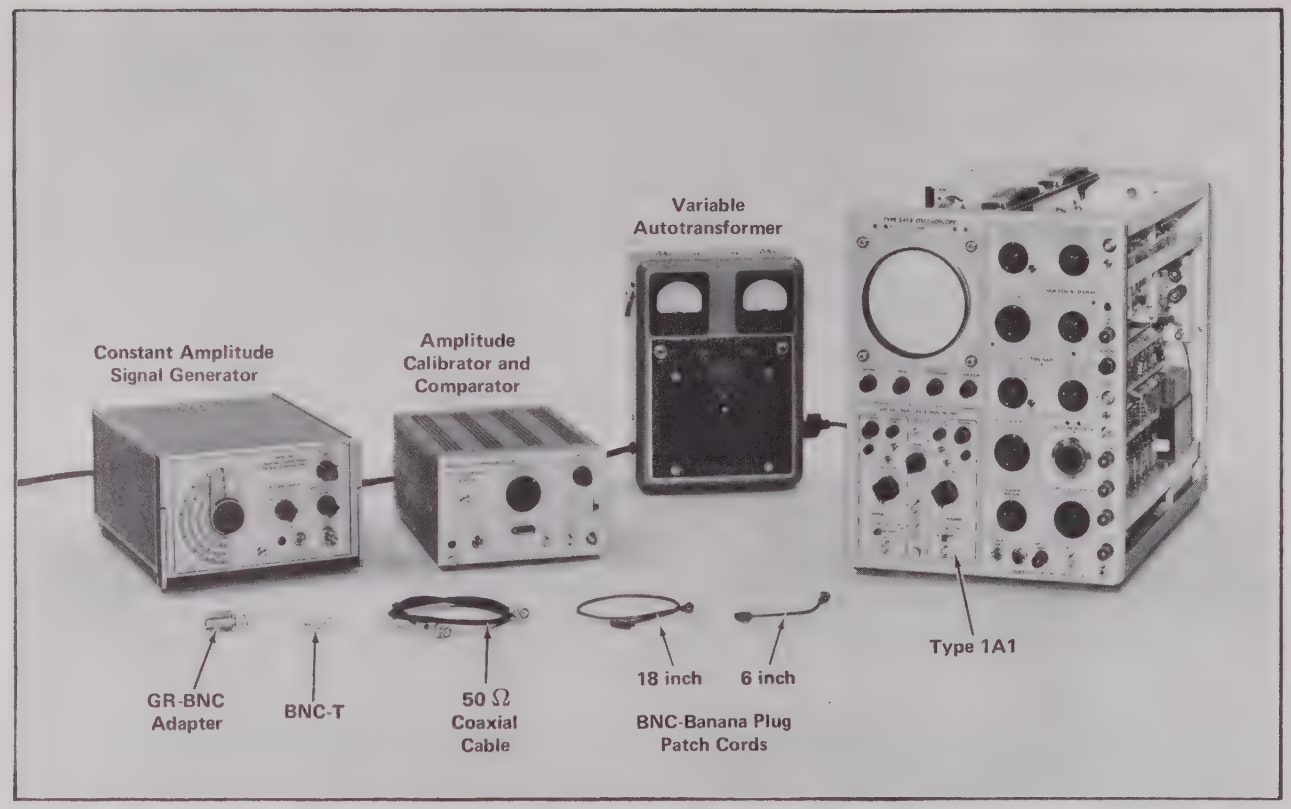


Fig. 5-21. Basic setup of equipment for steps 40 through 43.

40. Check/Adjust External Horizontal Amplifier DC Balance (EXT HORIZ DC BAL, R317)

REQUIREMENT: Ground reference (left side of display with positive-going input) should not shift more than 2 cm as the VARIABLE 10-1 control is rotated through its range.

a. Set the controls as listed in Table 5-16. The basic setup of equipment appears in Fig. 5-21.

CAUTION

Stationary dots can damage the CRT phosphor. Defocus the display while stationary dots are present on the CRT.

b. Connect an 18 inch BNC to banana plug patch cord (item 13) between the Input connector on the Vertical Plug-In Unit and the SAWTOOTH A connector.

WARNING

Approximately +150 V exists at the SAWTOOTH A jack.

c. Connect a BNC-T to the Oscilloscope Time Base A Trigger Input Connector. Connect a 42 inch coaxial cable from the T to the Amplitude Calibrator and Comparator Output connector. Connect a 6 inch BNC to banana plug patch cord from the T to the Oscilloscope HORIZ INPUT connector.

d. Set the Amplitude Calibrator and Comparator for a 1 volt square-wave output.

e. Adjust the A TRIGGERING LEVEL control for a stable display as in Fig. 5-22A. It may be necessary to adjust the HORIZONTAL POSITION controls to observe the display.

f. CHECK–Horizontal shift at the left side of the waveform should not be more than 2 cm as the VARIABLE 10-1 control is rotated through its range.

g. (Calibration Procedure only) ADJUST–EXT HORIZ DC BAL R317 (Fig. 5-22C) for minimum horizontal shift at the left side of the waveform as the VARIABLE 10-1 is rotated through its range.

41. Check/Adjust External Horizontal Amplifier X10 Input Compensation (C301C)

REQUIREMENT: The Horizontal Amplifier X10 position must pass a 1-kHz square wave whose overshoot, rounding or tilt does not differ from that of the X1 position display by more than 5% of the display's horizontal amplitude.

a. Equipment setup is continued from step 40.

b. Set the Amplitude Calibrator and Comparator for a 0.5 V output.

c. Turn the VARIABLE 10-1 control fully clockwise and center the display horizontally. Note the appearance of the bottom edge of the vertical display segments. See Fig. 5-22B.

d. Change the HORIZONTAL DISPLAY switch to EXT X10, and set the Amplitude Calibrator and Comparator to 5 V.

e. CHECK—The left to right rounding or overshoot at the bottom edge of the vertical segments should match the X1 waveform to within 5% of total left to right display amplitude. See Fig. 5-22B.

f. (Calibration Procedure only) ADJUST—C301C (Fig. 5-22C) as necessary to obtain optimum matching between bottoms of vertical segments of the X1 vs X10 displays. Mismatch should be within 5% of total left to right display.

42. Check External Horizontal Amplifier Deflection Factor

REQUIREMENT—Deflection factor should be 0.2 V or less per cm in X1 position, 2 V or less per cm in X10 position, and VARIABLE 10-1 must have a range of 10:1 or greater.

a. Equipment setup is continued from steps 40 and 41.

b. Set the HORIZONTAL DISPLAY switch to EXT X1 position. Check that the VARIABLE 10-1 control is fully clockwise.

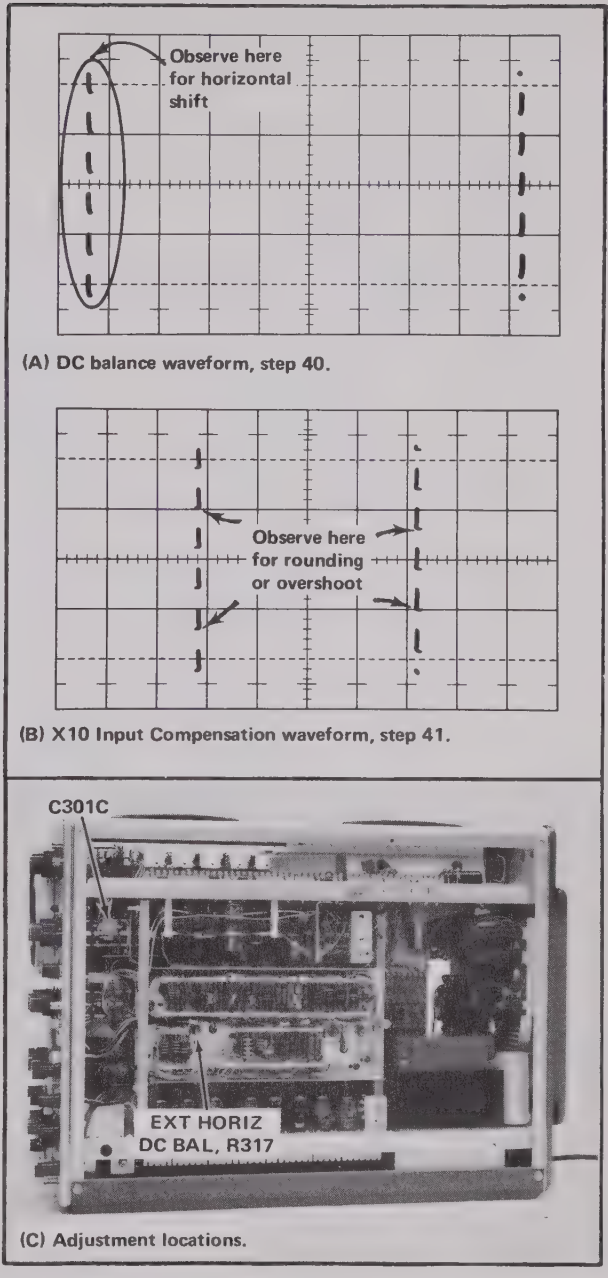

Observe here for horizontal shift
(A) DC balance waveform, step 40.
Observe here for rounding or overshoot
(B) X10 Input Compensation waveform, step 41.
C301C
EXT HORIZ DC BAL, R317
(C) Adjustment locations.

Fig. 5-22. External Horizontal Amplifier waveforms and adjustment locations.

c. Set the Amplitude Calibrator and Comparator to 1.

d. CHECK—For at least 5 cm horizontal separation between the two vertical lines. Record the actual amount of horizontal separation.

e. Set the HORIZONTAL DISPLAY switch to X10 and the Amplitude Calibrator and Comparator to 10 V.

f. CHECK—For horizontal separation between the two lines equal (±3%) to that in step d.

g. Set the VARIABLE 10-1 fully counterclockwise and turn the Amplitude Calibrator and Comparator to 50 V.

CAUTION

Do not apply more than 50 V to the EXT HORIZ Input.

h. CHECK—Horizontal display should be less than one-half of the amount observed in step f.

i. Turn the INTENSITY knob fully counterclockwise, extinguishing the display. Then disconnect the BNC-T and associated cables from the Oscilloscope and the Amplitude Calibrator and Comparator. See the HORIZONTAL DISPLAY switch to EXT X1 and the VARIABLE 10-1 control fully clockwise.

43. Check Horizontal Amplifier Bandwidth

REQUIREMENT—Bandwidth DC to 350 kHz or greater, measured at −3 dB point.

a. Control settings are as listed in Table 5-16. Basic setup of equipment appears in Fig. 5-21. A BNC to banana plug patch cord is connected from the SAWTOOTH A jack to the Vertical Plug-In Input jack.

b. Connect a BNC to banana plug patch cord from the Oscilloscope HORIZ INPUT to the Type 191 Constant Amplitude Signal Generator, using a GR to BNC female adapter at the Signal Generator. (The 6 inch BNC to Banana Plug patch cord can be connected to a 42 inch coaxial cable to provide enough cable length if a second 18 inch BNC to Banana Plug patch cord is not available.)

c. Check that the HORIZONTAL DISPLAY switch is at X1 and that the VARIABLE 10-1 control is fully clockwise. Set the Time Base A STABILITY control fully clockwise and increase the INTENSITY as necessary to observe the free-running display.

d. Set the Constant Amplitude Signal Generator for 50 kHz only and adjust its amplitude for 6 cm of horizontal deflection.

e. Change the Frequency Range switch on the signal generator to .35 MHz and check that at least 4.2 cm of display remains.

f. Switch the HORIZONTAL DISPLAY control to A. Disconnect the test equipment and patch cords.

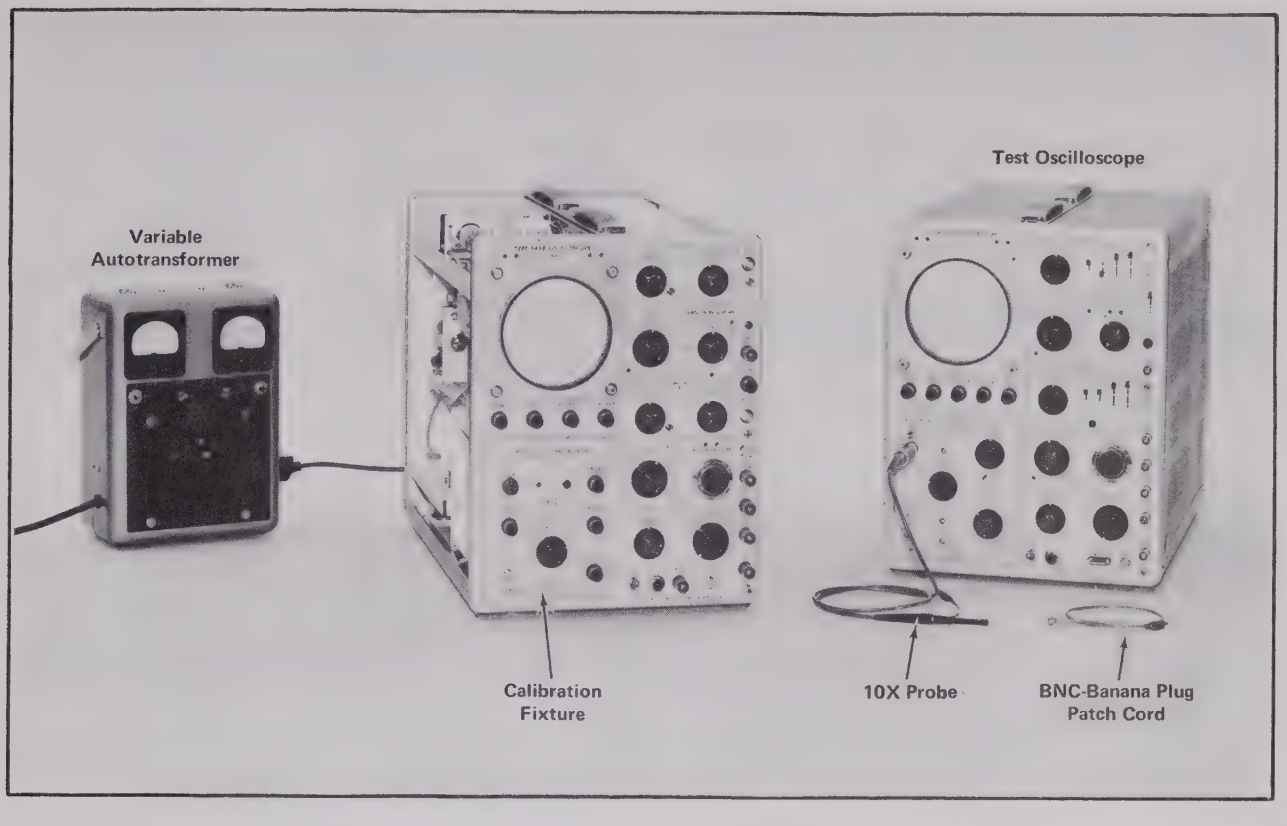


Fig. 5-23. Basic setup of equipment for steps 44 through 49.

TABLE 5-17

Basic Control Settings for Steps 44 through 49

Oscilloscope

CRT Controls	
FOCUS and ASTIGMATISM	Well focused display
INTENSITY	Adjusted for nominal brightness
HORIZONTAL DISPLAY	A
5X MAGNIFIER	OFF
Time Base A Controls	
TIME/CM	1 mSEC
VARIABLE	CALIBRATED
TRIGGER SLOPE	+INT
TRIGGERING MODE	AC
Time Base B Controls	
TIME/CM	1 mSEC
LENGTH	10 CM
TRIGGER SLOPE	+INT
TRIGGERING MODE	AUTO
HORIZONTAL POSITION	Midrange or centered display

Calibration Fixture

Test Function	+Pulse
Vertical Position	Centered display
Amplitude	Adjusted for 5 CM display
Repetition Rate	1 kHz or low

44. Check/Adjust Vertical Amplifier High Frequency Compensation (R502, R578, R551, L560, C577, C551, C568, L589, L599, R580, C520, C581, L554, L588, L598)

REQUIREMENT—Tilt, rounding or overshoot of fast rise square wave should not exceed ±1.25%, 2.5% peak to peak.

a. Turn the Oscilloscope off and install the Calibration Fixture in its plug-in compartment. Then turn the Oscilloscope on. Wait approximately 5 minutes before performing the next CHECK.

b. Set the controls as listed in Table 5-17. Basic setup of equipment appears in Fig. 5-23.

c. Adjust the Triggering controls as necessary to obtain a stable display.

d. CHECK—Tilt at the top of the waveform. It should not exceed approximately 0.6 mm. (0.625 mm is specified, but the display cannot be read that accurately.) See Fig. 5-24A and B.

e. Switch the Calibration Fixture Repetition Rate to 500 kHz or High, and the Oscilloscope Time Base A TIME/CM to .5 μSEC. Readjust the Triggering controls if necessary to maintain a stable display.

f. CHECK—Ringing, rounding, overshoot and tilt. It should not exceed approximately ±0.6 mm (1.25 mm peak-to-peak). See Fig. 5-24C and D.

g. (Calibration Procedure only) Set the controls as listed in Table 5-18. Then set the Oscilloscope on its right side and perform the indicated adjustments. If a "tuning-up" is being done, no presetting of adjustments is necessary. However, if the transient response adjustments are grossly in error and a general re-alignment is being performed, preset controls as follows: R578, R551, R580, L589, and L599 to mid-position; L588 and L598 to out position. Control locations are shown in Fig. 5-25. Use Fig. 5-24C as a reference waveform. Set the Oscilloscope upright after adjusting.

h. INTERACTION—If adjustments are performed, re-check GAIN (step 9) and Risetime (step 45).

45. Check Risetime

REQUIREMENT—Risetime should be 10 nanoseconds or less between the 10% and 90% amplitude points on a fast-rise pulse.

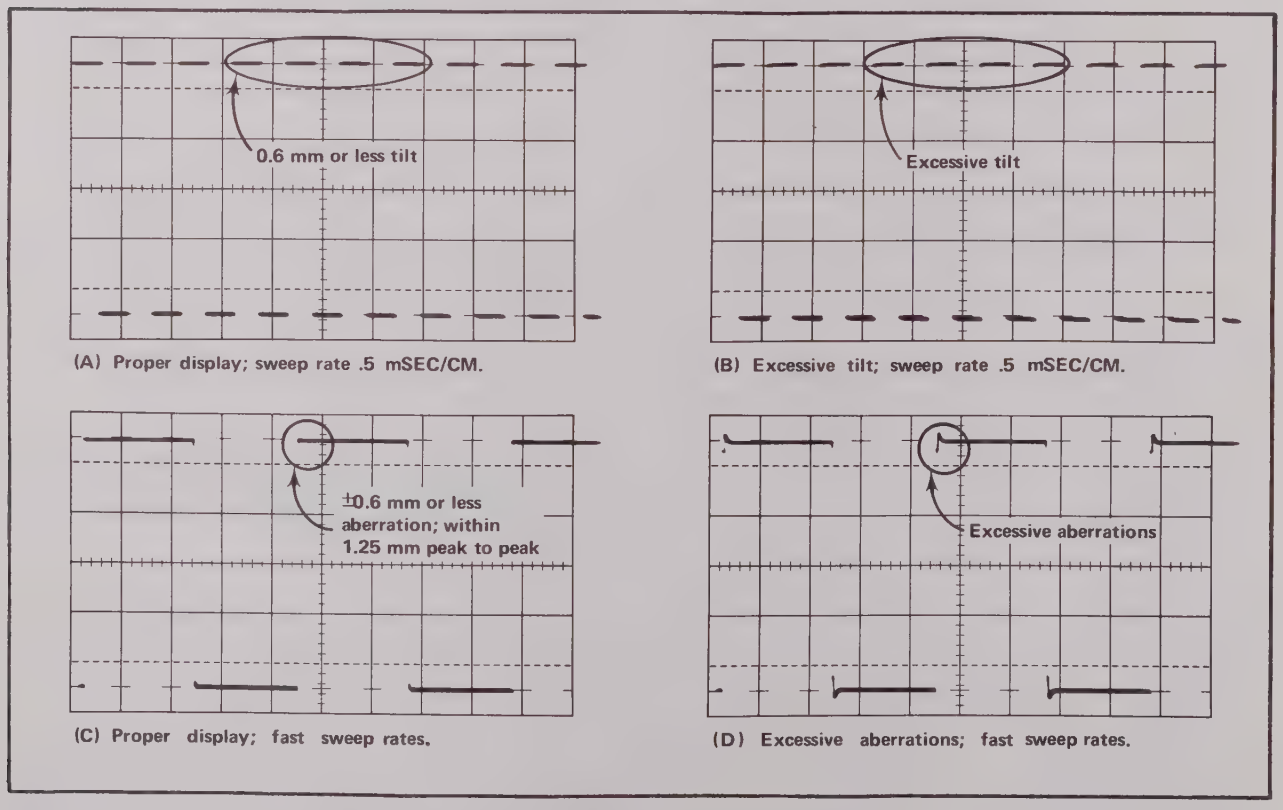

0.6 mm or less tilt
(A) Proper display; sweep rate .5 mSEC/CM.
Excessive tilt
(B) Excessive tilt; sweep rate .5 mSEC/CM.
±0.6 mm or less aberration; within 1.25 mm peak to peak
(C) Proper display; fast sweep rates.
Excessive aberrations
(D) Excessive aberrations; fast sweep rates.

Fig. 5-24. Vertical Amplifier frequency compensation waveforms; step 44.

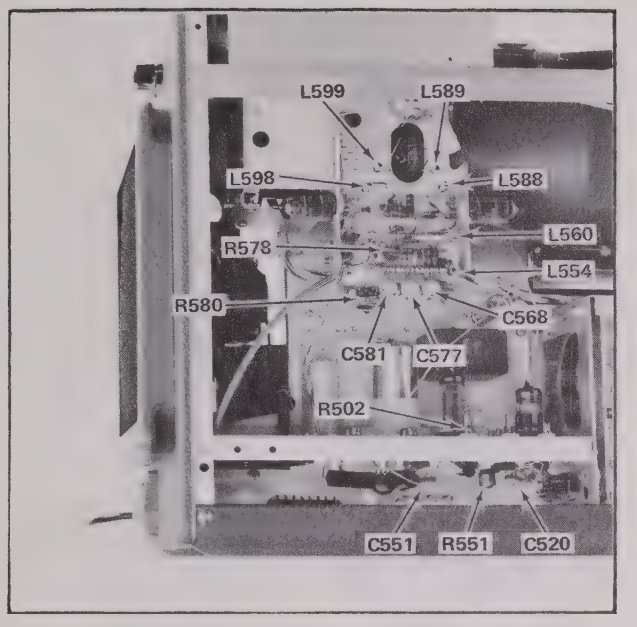


Fig. 5-25. Vertical Amplifier high frequency compensation adjustment location, step 44.

a. Control settings are as listed in Table 5-17 except that the Calibration Fixture Repetition Rate is at 500 kHz or High. The basic setup of equipment appears in Fig. 5-23.

b. Set the A TIME/CM switch to .1 μSEC.

c. Adjust the Calibration Fixture Amplitude control for 5 cm of vertical display. Then turn the 5X MAGNIFIER on and position the waveform as shown in Fig. 5-26.

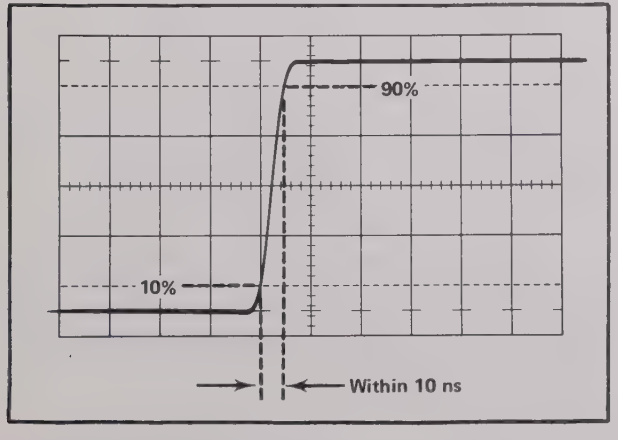


Fig. 5-26. Risetime waveform, step 45. Sweep rate 20 ns/cm (5X MAGNIFIER ON).

d. CHECK—Risetime measured between the 10% and 90% points should not exceed 10 nSEC (0.5 cm). See Fig. 5-26.

e. Turn the 5X MAGNIFIER off and switch the Time Base A TIME/CM to 1 mSEC.

f. Switch the Calibration Fixture Test Function control to 1 kHz or Low.

46. Check +GATE A and +GATE B Front Panel Outputs

REQUIREMENT— +GATE outputs must be 20 V or greater in amplitude, positive-going with base line at zero volts (ground). +GATE A waveform duration should be equal to approximately 10.5 times the selected 'A' TIME/CM value. +GATE B should be equal to a maximum of approximately 10.5 times the selected 'B' TIME/CM value, and should vary with the position of the 'B' LENGTH control.

a. Control settings listed in Table 5-17 apply. Basic setup of equipment appears in Fig. 5-23.

b. Set the Test Oscilloscope Time/div to 2 ms, its Volts/div to 1 Volt and its Triggering Slope to —INT.

c. Connect the 10X probe from the Test Oscilloscope to the +GATE A output connector on the Oscilloscope.

d. Set the Test Oscilloscope triggering controls as necessary to obtain a stable display.

e. CHECK—The Test Oscilloscope display amplitude should be a square wave of at least 2.5 divisions (25 V) referenced to ground; positive pulse width should be slightly over 5 divisions (10 ms). (Oscilloscope sweep duration 1 mSEC/cm; sweep length slightly over 10 cm).

f. Connect the Test Oscilloscope probe to the Oscilloscope + GATE B output connector.

g. CHECK—The Test Oscilloscope display should be approximately the same as in step e.

h. Remove the 10X probe from the +GATE B connector.

47. Check SAWTOOTH A Front Panel Output

REQUIREMENT—SAWTOOTH A output must be 130 V or greater in amplitude, positive-going, with the same time duration as the A time base.

a. Control settings given in Table 5-17 apply. Basic setup of equipment appears in Fig. 5-23.

b. Set the Test Oscilloscope deflection factor to 5 V/div. Connect a 10X probe to the Test Oscilloscope Vertical Input connector. Then connect the probe tip to the Oscilloscope SAWTOOTH A output connector.

WARNING

Approximately +150 V exists at the SAWTOOTH A jack.

c. CHECK—The Test Oscilloscope display should be a positive-going sawtooth, with a peak amplitude of at least 2.6 divisions (130 V) and a duration of approximately 5.25 divisions (10.5 mSEC).

48. Check VERT SIG OUT Front Panel Output

REQUIREMENT—VERT SIG OUT amplitude should be 1.2 V or greater for each centimeter of display.

a. Only the Vertical Plug-In Unit (Calibration Fixture) control settings and the POWER ON switch affect the VERT SIG OUT. The display is desired on the Oscilloscope only for comparison purposes.

b. The control settings given in Table 5-17 apply, except that the Calibration Fixture Amplitude control is set for a 5 division display.

c. Set the Test Oscilloscope Volts/div to .2 V/cm, providing 2 V/div in conjunction with the 10X probe. Connect the Test Oscilloscope 10X probe tip to the VERT SIG OUT connector on the Oscilloscope.

d. CHECK—The Test Oscilloscope display should be a square wave with an amplitude of at least 6 V (3 divisions). Because the vertical signal is AC-coupled to the VERT SIG OUT connector, approximately 2.3% tilt will appear on the Test Oscilloscope 1 kHz square wave display.

e. Disconnect the probe from the VERT SIG OUT jack.

49. Check DLY'D TRIG Front Panel Output

REQUIREMENT—DLY'D TRIG output should be a positive-going pulse of approximately 5 V amplitude occurring at the end of the delay period.

a. Control settings listed in Table 5-17 apply. Basic setup of equipment appears in Fig. 5-23.

b. Set the Oscilloscope A TIME/CM to 10 μSEC, turn the A STABILITY fully clockwise, and set the A TRIGGERING MODE switch to AC.

c. Connect an 18 inch BNC to banana jack patch cord between the DLY'D TRIG output connector and the Calibration Fixture EXT INPUT.

d. Switch the Calibration Fixture Test Function switch to Gain Set and adjust its Vertical Position control as necessary to observe the positive-going trigger pulse.

e. CHECK—The display on the Oscilloscope should be a positive-going pulse with an amplitude of at least 0.2 cm (5 V). The DELAY-TIME MULTIPLIER 1-10 control should move the pulse approximately 1 cm along the trace for each 1.00 dial movement.

f. Disconnect the patch cord from the Oscilloscope.

50. Check Vertical Amplifier Bandwidth (Optional)

NOTE

There is a relationship between risetime and upper bandwidth limit which can be expressed as follows:

$$Bandwidth \approx \frac{.35}{risetime}$$

The 10 ns risetime for which the system was checked in step 45 therefore indicates an upper frequency limit of 35 MHz for the Oscilloscope itself. When used with a calibrated 1A1, a system (1A1 — Oscilloscope) bandwidth of 33 MHz can be expected at 50 mV/cm. This sine wave bandwidth check therefore need not be performed unless the risetime check results were marginal.

REQUIREMENT—Bandwidth DC to 33 MHz or greater (with Type 1A1 Plug-In Unit).

a. Turn Oscilloscope off, remove the Calibration Fixture and install the Type 1A1 Vertical Plug-In; turn the Oscilloscope on and wait three minutes before performing the next CHECK.

b. Set the equipment controls as indicated in Table 5-19.

c. Connect a 50 Ω BNC termination to the Type 1A1 Ch 1 Input Connector.

d. Connect a 50 Ω coaxial cable from the 50 Ω termination to the Type 191 Constant Amplitude Signal Generator Output connector using a GR to BNC adapter.

TABLE 5-19

Control Settings for Step 50

Oscilloscope	
HORIZONTAL DISPLAY	A
5X MAGNIFIER	OFF
Time Base A Controls	
TIME/CM	.5 mSEC
STABILITY	Fully clockwise
TRIGGERING MODE	AC
HORIZONTAL POSITION	Midrange or centered display
Vertical Plug-In Unit (Type 1A1)	
Volts/Cm	.05 V
Mode	CH 1
Input Selector	AC

e. Without changing the Amplitude control, change the Frequency Range switch on the Signal Generator to the 18-42 MHz range and select 33 MHz output.

f. CHECK—Display amplitude should be at least 2.8 cm, indicating not more than 3 dB attenuation at 33 MHz. At least 2.8 cm display amplitude should be present at all frequencies below 33 MHz.

This completes the procedure. If the Oscilloscope has been completely calibrated to the tolerances given in this procedure, it will perform to the specifications given in the Specifications section of this manual.

NOTES

PARTS LIST ABBREVIATIONS

BHB	binding head brass
BHS	binding head steel
cap.	capacitor
cer	ceramic
comp	composition
conn	connector
CRT	cathode-ray tube
csk	countersunk
DE	double end
dia	diameter
div	division
elect.	electrolytic
EMC	electrolytic, metal cased
EMT	electrolytic, metal tubular
ext	external
F & I	focus and intensity
FHB	flat head brass
FHS	flat head steel
Fil HB	fillister head brass
Fil HS	fillister head steel
h	height or high
hex.	hexagonal
HHB	hex head brass
HHS	hex head steel
HSB	hex socket brass
HSS	hex socket steel
ID	inside diameter
incd	incandescent
int	internal
lg	length or long
met.	metal
mtg hdw	mounting hardware
OD	outside diameter
OHB	oval head brass
OHS	oval head steel
PHB	pan head brass
PHS	pan head steel
plstc	plastic
PMC	paper, metal cased
poly	polystyrene
prec	precision
PT	paper, tubular
PTM	paper or plastic, tubular, molded
RHB	round head brass
RHS	round head steel
SE	single end
SN or S/N	serial number
SW	switch
TC	temperature compensated
THB	truss head brass
thk	thick
THS	truss head steel
tub.	tubular
var	variable
w	wide or width
WW	wire-wound

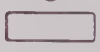
PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix, Inc. Field Office or representative.

Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number, instrument type or number, serial or model number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix, Inc. Field Office or representative will contact you concerning any change in part number.

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number
00X	Part removed after this serial number
*000-0000-00	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, Inc., or reworked or checked components.
Use 000-0000-00	Part number indicated is direct replacement.
	Screwdriver adjustment.
	Control, adjustment or connector.

SECTION 6
ELECTRICAL PARTS LIST

Values are fixed unless marked Variable.

Ckt. No.	Tektronix Part No.	Description				S/N Range
		Bulbs				
B129	150-030	Neon, NE-2 V	READY			
B160W	150-030	Neon, NE-2 V	UNCALIBRATED			
B167	150-027	Neon, NE-23				
B171	150-027	Neon, NE-23				
B267	150-027	Neon, NE-23				
B271	150-027	Neon, NE-23				
B347	150-030	Neon, NE-2 V				
B386	150-027	Neon, NE-23				
B397	150-030	Neon, NE-2 V				
B398	150-030	Neon, NE-2 V				
B434A	150-030	Neon, NE-2 V	Delay Time Multiplier Indicator Lights			
B434B	150-030	Neon, NE-2 V				
B538	150-030	Neon, NE-2 V				
B539	150-030	Neon, NE-2 V				
B601	150-031	Incandescent #44	Graticule Light			
B602	150-031	Incandescent #44	Graticule Light			
B603	150-001	Incandescent #47	Pilot Light			
		Capacitors				

Tolerance ±20% unless otherwise indicated.
Tolerance of all electrolytic capacitors as follows (with exceptions):

3 V — 50 V = −10%, +250%
51 V — 350 V = −10%, +100%
351 V — 450 V = −10%, + 50%

C1	281-534	3.3 pf	Cer	500 v	±0.25 pf	
C6	283-006	0.02 μf	Cer	600 v		
C9	281-529	1.5 pf	Cer	500 v	±0.25 pf	
C10	285-543	0.0022 μf	PTM	400 v		
C11	281-523	100 pf	Cer	350 v		
C15	283-000	0.001 μf	Cer	500 v		
C20	283-000	0.001 μf	Cer	500 v		
C24	283-004	0.02 μf	Cer	150 v		
C32	283-004	0.02 μf	Cer	150 v		
C36	283-057	0.1 μf	Cer	200 v		
C48	283-006	0.02 μf	Cer	600 v		
C49	290-158	50 μf	EMT	25 v	−15%, +75%	100-409
C49	290-0287-00	47 μf	EMT	25 v		410-up
C51	Use 281-0504-00	10 pf	Cer	500 v	10%	
C56	283-002	0.01 μf	Cer	500 v		
C60	285-501	0.001 μf	PTM	600 v		
C61	281-501	4.7 pf	Cer	500 v	±1 pf	
C65	283-000	0.001 μf	Cer	500 v		

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Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
C70	283-000	0.001 μf	Cer		500 v		
C74	283-004	0.02 μf	Cer		150 v		
C76	283-057	0.1 μf	Cer		200 v		
C81	281-523	100 pf	Cer		350 v		
C87	281-513	27 pf	Cer		500 v		
C90	290-114	47 μf	EMC		6 v		
C95	283-023	0.1 μf	Cer		10 v		
C102	281-511	22 pf	Cer		500 v	10%	
C103	283-000	0.001 μf	Cer		500 v		
C105	283-000	0.001 μf	Cer		500 v		
C109	283-001	0.005 μf	Cer		500 v		
C116	283-000	0.001 μf	Cer		500 v		
C123	281-504	10 pf	Cer		500 v	10%	
C129	283-001	0.005 μf	Cer		500 v		
C131	281-513	27 pf	Cer		500 v		
C134	281-503	8 pf	Cer		500 v	±0.5 pf	
C138	283-001	0.005 μf	Cer		500 v		
C141	281-503	8 pf	Cer		500 v	±0.5 pf	
C150	281-528	82 pf	Cer		500 v	10%	
C151	283-001	0.005 μf	Cer		500 v		
C157	281-506	12 pf	Cer		500 v	10%	
C160A	281-007	3-12 pf	Cer	Var			
C160B	283-534	82 pf	Mica		500 v	5%	
C160C	281-010	4.5-25 pf	Cer	Var			
C160D	283-534	82 pf	Mica		500 v	5%	
C160E	281-010	4.5-25 pf	Cer	Var			
C160F	*291-008	0.001 μf				±½%	100-6189
C160G		0.01 μf					
C160H	*291-007	0.1 μf		Timing Series		±½%	100-6189
C160J		1 μf					
C160F †		0.001 μf					
C160G †		0.01 μf					
C160H †	*295-0102-00	0.1 μf	Timing Capacitor Assembly				6190-up
C160J †		1 μf					
C160K	281-543	270 pf	Cer		500 v	10%	
C165	281-525	470 pf	Cer		500 v		
C167	283-000	0.001 μf	Cer		500 v		
C180A	283-536	220 pf	Mica		500 v	10%	
C180B	285-543	0.0022 μf	PTM		400 v		
C180C	285-515	0.022 μf	PTM		400 v		
C180D	285-526	0.1 μf	PTM		400 v		
C180E	285-526	0.1 μf	PTM		400 v		
C181	281-515	27 pf	Cer		500 v	±1.35 pf	
C187	283-001	0.005 μf	Cer		500 v		
C190	281-509	15 pf	Cer		500 v	10%	
C193	283-001	0.005 μf	Cer		500 v		
C196	283-000	0.001 μf	Cer		500 v		
C201	283-001	0.005 μf	Cer		500 v		
C203	283-001	0.005 μf	Cer		500 v		

†C160 F, G, H, J and C260 D, E, F, G (S/N 6190-up) furnished as a unit.

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
C214	283-002	0.01 μf	Cer		500 v		
C215	283-000	0.001 μf	Cer		500 v		
C231	281-513	27 pf	Cer		500 v		
C234	281-518	47 pf	Cer		500 v		
C241	281-534	3.3 pf	Cer		500 v	±0.25 pf	
C250	281-516	39 pf	Cer		500 v	10%	
C260A	281-007	3-12 pf	Cer	Var			
C260B	283-533	39 pf	Mica		500 v	5%	
C260C	281-012	7-45 pf	Cer	Var			
C260D	*291-026	480 pf					
C260E		0.005 μf					
C260F		0.05 μf		Timing Series		±½%	100-6189
C260G		0.5 μf					
†C260D	*295-0102-00	480 pf	Timing Capacitor Assembly				6190-up
†C260E		0.005 μf					
†C260F		0.05 μf					
†C260G		0.5 μf					
C267	283-000	0.001 μf	Cer		500 v		
C280A	281-510	22 pf	Cer		500 v		
C280B	281-525	470 pf	Cer		500 v		
C280C	285-506	0.0047 μf	PTM		400 v		
C280D	285-519	0.047 μf	PTM		400 v		
C280E	285-519	0.047 μf	PTM		400 v		
C295	281-509	15 pf	Cer		500 v	10%	
C301C	281-012	7-45 pf	Cer	Var			
C301E	281-546	330 pf	Cer		500 v	10%	
C301H	281-506	12 pf	Cer		500 v	10%	
C307	285-0562-00	0.47 μf	PTM		400 v		X8590-up
C320	283-001	0.005 μf	Cer		500 v		
C330	281-010	4.5-25 pf	Cer	Var			
C336	283-001	0.005 μf	Cer		500 v		
C340	281-501	4.7 pf	Cer		500 v	±1 pf	
C347	283-000	0.001 μf	Cer		500 v		
C348	281-007	3-12 pf	Cer	Var			
C355	281-526	1.5 pf	Cer		500 v	±0.5 pf	
C356	283-001	0.005 μf	Cer		500 v		
C364	281-538	1 pf	Cer		500 v		
C375	281-023	9-180 pf	Mica	Var			
C380	290-000	6.25 μf	EMT		300 v		100-8879
C380	290-0405-00	10 μf	EMT		150 v		8880-up
C384	281-538	1 pf	Cer		500 v		
C390	281-501	4.7 pf	Cer		500 v	±1 pf	
C393	285-519	0.047 μf	PTM		400 v		
C396	283-001	0.005 μf	Cer		500 v		
C421	283-002	0.01 μf	Cer		500 v		
C426	283-001	0.005 μf	Cer		500 v		
C444	281-511	22 pf	Cer		500 v	10%	
C454	281-518	47 pf	Cer		500 v		
C457	283-001	0.005 μf	Cer		500 v		
C471	Use 290-185	2 x 40 μf	EMC		250 v		
C472	283-003	0.01 μf	Cer		150 v		

†C260 D, E, F, G and C160 F, G, H, J (S/N 6190-up), furnished as a unit.

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
C475	285-526	0.1 μf	PTM		400 v		
C476A†	Use 290-0062-00	40 μf	EMC		475 v		
C476B†	Use 290-0062-00	20 μf	EMC		475 v		
C476C†	Use 290-0062-00	10 μf	EMC		475 v		
C477	285-526	0.1 μf	PTM		400 v		
C489	281-593	3.9 pf	Cer		500 v	10%	
C493	283-002	0.01 μf	Cer		500 v		
C506	285-526	0.1 μf	PTM		400 v		
C513	283-088	0.0011 μf	Cer		500 v	5%	
C520	281-022	8-50 pf	Cer	Var			
C523	283-088	0.0011 μf	Cer		500 v	5%	
C533	283-002	0.01 μf	Cer		500 v		
C535	283-003	0.01 μf	Cer		150 v		
C536	283-002	0.01 μf	Cer		500 v		
C543	283-002	0.01 μf	Cer		500 v		
C546	285-517	0.022 μf	PTM		600 v		
C550	281-0603-00	39 pf	Cer		500 v	5%	X11150-up
C551	281-601	7.5 pf	Cer		500 v	±0.5 pf	100-219
C551	281-075	5-25 pf	Cer	Var			220-up
C556	283-103	180 pf	Cer		500 v	5%	
C557	283-077	330 pf	Cer		500 v	5%	
C566	283-103	180 pf	Cer		500 v	5%	
C567	283-084	270 pf	Cer		1000 v	5%	
C568	281-022	8-50 pf	Cer	Var			100-6839
C568	281-0013-00	8-50 pf	Cer	Var			6840-up
C570	283-000	0.001 μf	Cer		500 v		
C572	283-006	0.02 μf	Cer		600 v		
C574	281-602	68 pf	Cer		500 v	5%	
C577	281-0013-00	8-50 pf	Cer	Var			X6840-up
C578	281-536	0.001 μf	Cer		500 v	10%	
C579	281-543	270 pf	Cer		500 v	10%	
C580	281-513	27 pf	Cer				
C581	281-022	8-50 pf	Cer	Var	500 v		100-6839
C581	281-0013-00	8-50 pf	Cer	Var			6840-up
C582	283-088	0.0011 μf	Cer		500 v	5%	
C590	283-006	0.02 μf	Cer		600 v		
C592	283-088	0.0011 μf	Cer		500 v	5%	
C597	283-000	0.001 μf	Cer		500 v		
C601	283-057	0.1 μf	Cer		200 v		
C610	285-510	0.01 μf	PTM		400 v		
C617	285-510	0.01 μf	PTM		400 v		
C628	285-510	0.01 μf	PTM		400 v		
C640	Use 290-016	125 μf	EMC		350 v		
C648	283-002	0.01 μf	Cer		500 v		
C649	Use 290-012	2 x 40 μf	EMC		250 v		
C650	285-510	0.01 μf	PTM		400 v		
C670	Use 290-019	150 μf	EMC		250 v		
C671	Use 290-019	150 μf	EMC		250 v		
C679A,B,C	Use 290-005	3 x 10 μf	EMC		450 v		
C680	285-510	0.01 μf	PTM		400 v		

†C476A,B,C furnished as a unit.

Capacitors *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description				S/N Range
C688	285-510	0.01 μf	PTM	400 v		
C700	Use 290-017	125 μf	EMC	450 v		
C710	285-511	0.01 μf	PTM	600 v		100-11329
C710	285-0517-00	0.022 μf	MT	600 v		11330-up
C730	Use 290-016	125 μf	EMC	350 v		
C740	285-510	0.01 μf	EMC	400 v		
C760A,B	Use 290-013	2 x 40 μf	EMC	450 v		
C780	283-001	0.005 μf	Cer	500 v		
C783	283-002	0.01 μf	Cer	500 v		
C785	283-002	0.01 μf	Cer	500 v		
C802	Use 290-190	40 μf	EMC	400 v		
C803	283-000	0.001 μf	Cer	500 v		
C806	285-506	0.0047 μf	PTM	400 v		
C808	285-502	0.001 μf	PTM	1000 v		
C820	283-082	0.01 μf	Cer	4000 v		
C821	283-082	0.01 μf	Cer	4000 v		
C822	281-525	470 pf	Cer	500 v		
C823	283-101	0.0047 μf	Cer	6000 v		
C824	285-555	0.1 μf	PTM	100 v		
C829	283-082	0.01 μf	Cer	4000 v		
C830	283-082	0.01 μf	Cer	4000 v		
C833	281-556	500 pf	Cer	10000 v		
C834	281-556	500 pf	Cer	10000 v		
C836	283-096	500 pf	Cer	20000 v		
C841	283-006	0.02 μf	Cer	600 v		
C842	283-082	0.01 μf	Cer	4000 v		
C852	283-082	0.01 μf	Cer	4000 v		
C854	283-082	0.01 μf	Cer	4000 v		
C858	283-082	0.01 μf	Cer	4000 v		
C863	283-002	0.01 μf	Cer	500 v		
C871	283-077	330 pf	Cer	500 v	5%	
C874	283-077	330 pf	Cer	500 v	5%	
C885	281-513	27 pf	Cer	500 v		
C897	283-000	0.001 μf	Cer	500 v		

Diodes

D29	Use *152-185	Silicon Replaceable by 1N4152				
D30	Use *152-185	Silicon Replaceable by 1N4152				
D32	Use *152-185	Silicon Replaceable by 1N4152				
D43	152-064	Zener	1N961	10 V, 10%		100-9549
D43	152-0149-00	Zener	1N961B	0.4 W, 10 V, 5%		9550-up
D46	152-141	Silicon	1N4152			100-11119
D46	152-0141-02	Silicon	1N4152			11120-up
D47	152-141	Silicon	1N4152			100-11119
D47	152-0141-02	Silicon	1N4152			11120-up
D48	*152-0185-00	Silicon Replaceable by 1N4152				X410-up
D49	152-126	Zener	1N3024A	1 W, 15 V, 10%		100-9549
D49	152-0024-00	Zener	1N3024B	1 W, 15 V, 5%		9550-up
D78	Use *152-185	Silicon Replaceable by 1N4152				
D79	Use *152-185	Silicon Replaceable by 1N4152				
D81	Use *152-185	Silicon Replaceable by 1N4152				

Diodes *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description	S/N Range
D82	Use *152-185	Silicon Replaceable by 1N4152	
D90	*152-0185-00	Silicon Replaceable by 1N4152	X410-up
D122	152-008	Germanium	
D131	152-008	Germanium	
D133	*152-061	Silicon Tek Spec	
D152	152-0246-00	Silicon Low leakage 0.25 W, 40 V	X4870-up
D231	152-008	Germanium	
D233	*152-061	Silicon Tek Spec	
D252	152-0246-00	Silicon Low leakage 0.25 W, 40 V	X4870-up
D307	152-0242-00	Silicon 1N486A	X8590-up
D642A,B,C,D	152-066	Silicon 1N3194	
D672A,B,C,D	152-066	Silicon 1N3194	
D679	152-066	Silicon 1N3194	
D702A,B	152-066	Silicon 1N3194	
D731	152-0066-00	Silicon 1N3194	X11330-up
D732A,B	152-066	Silicon 1N3194	
D762A,B,C,D	152-066	Silicon 1N3194	
D803	*152-0107-00	Silicon Replaceable by 1N647	X6780-up
D804	152-0265-00	Zener 1N970B 0.4 W, 25 V, 5%	X6780-up

Fuses

F601	159-011	6.25 Amp 3AG Slo-Blo, 115 v, 50-60 and 400 cps	
	159-005	3 Amp 3AG Slo-Blo, 230 v, 50-60 and 400 cps	
F602	159-0005-00	3 Amp 3AG Slo-Blo, 230 v, 50-60 and 400 cps	X8880-up

Relays

K600	148-021	Relay Delay	
K601	148-016	45 v DC	

Inductors

LR45	*108-293	27 μh (wound on a 680 Ω resistor)			
L75	*108-245	3.9 μh			
LR84	*108-294	300 μh (wound on a 2.7 k resistor)			
LR149	*108-164	1.2 mh (wound on a 3.6 k resistor)			
L249	*108-165	4.7 mh			
L424	*108-015	255 μh			
L528†	*308-318	8 μh 1.5 k 2 w WW 1%			
LR529	*108-292	12 μh (wound on a 100 Ω resistor)			
L533	276-507	Core, Ferrite			
L545	*108-262	0.6 μh			100-459X
L546	*108-262	0.6 μh			
L551	*108-260	0.1 μh			
L553	*119-034	Delay Line Assy			
L554	*114-091	2.7-5.4 μh	Var	Core 276-506	100-6839
L554	*114-0226-00	2.7-5.4 μh	Var	Core 276-0506-00	6840-up
L560	*114-130	1.45-2.9 μh	Var	Core 276-506	100-6839
L560	*114-0224-00	1.45-2.9 μh	Var	Core 276-0506-00	6840-up
L561	*108-181	0.2 μh			
L587	276-541	Core, Ferrite			X270-up
L588	*114-079	1.8-3.7 μh	Var	Core 276-506	100-6839
L588	*114-0225-00	1.8-3.7 μh	Var	Core 276-0506-00	6840-up
L589	*114-164	6-11 μh	Var	Core 276-506	100-6839
L589	*114-0227-00	6-11 μh	Var	Core 276-0506-00	6840-up
L597	276-541	Core, Ferrite			X270-up

†Coil, resistor combination.

Inductors (Cont'd)

Ckt. No.	Tektronix Part No.	Description			S/N Range
L598	*114-079	1.8-3.7 μh	Var	Core 276-506	100-6839
L598	*114-0225-00	1.8-3.7 μh	Var	Core 276-0506-00	6840-up
L599	*114-164	6-11 μh	Var	Core 276-506	100-6839
L599	*114-0227-00	6-11 μh	Var	Core 276-0506-00	6840-up
L778	Use *108-323	Beam Rotator			

Transistors

Q34	Use *151-0127-00	Selected from 2N2369			
Q35	Use *151-0127-00	Selected from 2N2369			
Q45	Use *151-0127-00	Selected from 2N2369			
Q85	*151-126	Replaceable by 2N2484			
Q95	*151-126	Replaceable by 2N2484			
Q307	151-0150-00	2N3440			X8590-up
Q513	*151-121	Selected from 2N3118			
Q514	*151-127	Selected from 2N2369			
Q523	*151-121	Selected from 2N3118			
Q524	*151-127	Selected from 2N2369			
Q534	*151-096	Selected from 2N1893			
Q543	*151-121	Selected from 2N3118			
Q584	*151-127	Selected from 2N2369			
Q594	*151-127	Selected from 2N2369			

Resistors

Resistors are fixed, composition, ±10% unless otherwise indicated.

R1	301-684	680 k	½ w		5%	
R2	301-394	390 k	½ w		5%	
R3	311-023	50 k		Var	INT TRIG DC LEVEL	
R4	302-104	100 k	½ w			
R6	302-106	10 meg	½ w			
R9	302-225	2.2 meg	½ w			
R12	302-105	1 meg	½ w			
R13	302-104	100 k	½ w			
R15	302-474	470 k	½ w			
R17†	311-096	100 k		Var	TRIGGERING LEVEL	
R18	302-223	22 k	½ w			
R19	302-474	470 k	½ w			
R20	302-563	56 k	½ w			
R22	302-470	47 Ω	½ w			
R23	302-470	47 Ω	½ w			
R24	302-222	2.2 k	½ w			
R26	Use 303-123	12 k	1 w		5%	100-9549
R26	303-0303-00	30 k	1 w		5%	9550-up
R27	306-223	22 k	2 w			100-459
R27	306-0153-00	15 k	2 w			460-up
R28	301-0393-00	39 k	½ w		5%	X9550-up
R29	301-623	62 k	½ w		5%	
R31	301-182	1.8 k	½ w		5%	
R32	302-152	1.5 k	½ w			
R33	302-124	120 k	½ w			
R34	305-123	12 k	2 w		5%	
R35	303-223	22 k	1 w		5%	
R36	302-100	10 Ω	½ w			
R37	301-103	10 k	½ w		5%	

†Furnished as a unit with R110 and SW110.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R38	Use 303-183	18 k	1 w			5%	
R39	311-026	100 k		Var		TRIG LEVEL CENTERING	100-9549
R39	311-0032-00	250 k		Var		TRIG LEVEL CENTERING	9550-up
R43	305-113	11 k	2 w			5%	100-409
R43	308-0364-00	9.65 k	3 w		WW	1%	410-up
R44	302-680	68 Ω	½ w				
R46	305-103	10 k	2 w			5%	100-409
R46	308-0301-00	10 k	3 w		WW	1%	410-up
R47	311-308	50 Ω		Var		TRIG SENS	
R48	305-103	10 k	2 w			5%	
R49	308-252	390 Ω	3 w		WW	5%	
R51	301-684	680 k	½ w			5%	
R52	301-394	390 k	½ w			5%	
R53	311-125	50 k	0.2 w	Var		INT TRIG DC LEVEL	
R54	302-104	100 k	½ w				
R56	302-106	10 meg	½ w				
R61	302-225	2.2 meg	½ w				
R62	302-105	1 meg	½ w				
R65	302-474	470 k	½ w				
R67†	311-096	100 k		Var		TRIGGERING LEVEL	
R68	302-223	22 k	½ w				
R69	302-474	470 k	½ w				
R70	302-563	56 k	½ w				
R72	302-470	47 Ω	½ w				
R73	302-470	47 Ω	½ w				
R74	302-332	3.3 k	½ w				
R75	301-242	2.4 k	½ w			5%	
R76	302-100	10 Ω	½ w				
R77	303-393	39 k	1 w			5%	
R78	301-753	75 k	½ w			5%	
R79	303-393	39 k	1 w			5%	
R81	301-153	15 k	½ w			5%	
R82	311-026	100 k		Var		TRIG LEVEL CENTERING	
R85	301-331	330 Ω	½ w			5%	
R87	301-432	4.3 k	½ w			5%	
R88	303-123	12 k	1 w			5%	
R90	301-432	4.3 k	½ w			5%	
R92	Use 303-0203-00	20 k	1 w			5%	
R93	302-561	560 Ω	½ w				
R95	302-152	1.5 k	½ w				
R97	303-223	22 k	1 w			5%	
R101	302-102	1 k	½ w				
R102	302-0223-00	20 k	½ w				
R103	302-226	22 meg	½ w				
R105	302-394	390 k	½ w				
R106	302-105	1 meg	½ w				
R107	302-470	47 Ω	½ w				
R109	302-224	220 k	½ w				

†Furnished as a unit with R210 and SW210.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R110†	311-096	100 k		Var		STABILITY	
R111	311-219	200 k	0.2 w	Var		PRESET ADJUST	
R114	301-914	910 k	½ w			5%	
R115	301-104	100 k	½ w			5%	
R116	301-184	180 k	½ w			5%	
R121	302-470	47 Ω	½ w				
R122	304-683	68 k	1 w				
R123	302-274	270 k	½ w				
R124	302-474	470 k	½ w				
R125	311-023	50 k		Var		LOCKOUT LEVEL	
R126	302-104	100 k	½ w				
R127	302-470	47 Ω	½ w				
R128	302-123	12 k	½ w				
R129	302-103	10 k	½ w				
R130	306-223	22 k	2 w				
R131	308-077	1 k	3 w		WW		
R132	302-470	47 Ω	½ w				
R133	302-104	100 k	½ w				
R134	*310-555	6 k/3 k	3 w				
R137	302-470	47 Ω	½ w				
R138	302-470	47 Ω	½ w				
R141	324-339	33.2 k	1 w		Prec	1%	
R143	324-335	30.1 k	1 w		Prec	1%	
R144	308-294	8 k	5 w		WW		
R146	302-470	47 Ω	½ w				
R147	302-102	1 k	½ w				
R148	302-473	47 k	½ w				
R150	302-271	270 Ω	½ w				
R151	301-683	68 k	½ w			5%	
R152	301-105	1 meg	½ w			5%	
R153	302-103	10 k	½ w				100-7289
R153	302-0470-00	47 Ω	½ w				7290-up
R154	302-0685-00	6.8 meg	½ w				X5490-up
R155	302-185	1.8 meg	½ w				
R156	302-105	1 meg	½ w				
R157	302-474	470 k	½ w				
R158	302-102	1 k	½ w				
R159	306-332	3.3 k	2 w				
R160A	309-045	100 k	½ w		Prec	1%	
R160B	309-051	200 k	½ w		Prec	1%	
R160C	309-003	500 k	½ w		Prec	1%	
R160D	309-014	1 meg	½ w		Prec	1%	
R160E	309-023	2 meg	½ w		Prec	1%	
R160F	309-087	5 meg	½ w		Prec	1%	
R160G	310-107	10 meg	1 w		Prec	1%	
R160H	310-107	10 meg	1 w		Prec	1%	
R160J	310-505	30 meg	2 w		Prec	1%	

†Furnished as a unit with R17 and SW110.

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Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R160T	304-563	56 k	1 w				
R160V	302-105	1 meg	½ w				
R160W	302-104	100 k	½ w				
R160X	302-103	10 k	½ w				
R160Y†	311-108	20 k		Var		VARIABLE	
R160Z	311-066	500 Ω	0.2 w	Var			
R164	306-223	22 k	2 w				
R165	306-223	22 k	2 w				
R166	306-223	22 k	2 w				
R167	302-155	1.5 meg	½ w				
R168	302-473	47 k	½ w				
R171	302-470	47 Ω	½ w				
R172	302-470	47 Ω	½ w				
R173	302-471	470 Ω	½ w				
R174	308-294	8 k	5 w		WW	5%	
R176	311-008	2 k		Var		SWP LENGTH	
R178	308-051	4 k	5 w		WW	5%	
R180A	302-474	470 k	½ w				
R180B	302-475	4.7 meg	½ w				
R181	302-475	4.7 meg	½ w				
R183	302-470	47 Ω	½ w				
R186	302-470	47 Ω	½ w				
R187	302-470	47 Ω	½ w				
R189	306-563	56 k	2 w				
R190	302-473	47 k	½ w				
R191	301-114	110 k	½ w			5%	
R192	302-470	47 Ω	½ w				
R193	302-470	47 Ω	½ w				
R194	304-472	4.7 k	1 w				
R196	302-104	100 k	½ w				
R199	304-104	100 k	1 w				
R201	302-470	47 Ω	½ w				
R203	302-470	47 Ω	½ w				
R210††	311-096	100 k		Var		STABILITY	
R211	311-110	100 k		Var		PRESET ADJUST	
R214	301-914	910 k	½ w			5%	
R215	301-114	110 k	½ w			5%	100-4869
R215	301-0104-00	100 k	½ w			5%	4870-up
R216	301-154	150 k	½ w			5%	
R221	302-101	100 Ω	½ w				
R230	304-223	22 k	1 w				

†Concentric with SW160 and SW160Y. Furnished as a unit with SW160Y.

††Furnished as a unit with R67 and SW210.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R231	301-472	4.7 k	½ w			5%	
R232	302-101	100 k	½ w				
R233	302-104	100 k	½ w				100-4869
R233	301-0104-00	100 k	½ w			5%	4870-up
R234	301-682	6.8 k	½ w			5%	100-4869
R234	323-0269-00	6.19 k	½ w		Prec	1%	4870-up
R235	301-682	6.8 k	½ w			5%	100-4869
R235	323-0269-00	6.19 k	½ w		Prec	1%	4870-up
R236	301-622	6.2 k	½ w			5%	
R237	301-274	270 k	½ w			5%	
R241	324-339	33.2 k	1 w		Prec	1%	
R243	324-335	30.1 k	1 w		Prec	1%	
R244	308-108	15 k	5 w		WW	5%	100-4869
R244	308-0320-00	15.6 k	3 w		WW	1%	4870-up
R246	302-101	100 Ω	½ w				
R247	302-222	2.2 k	½ w				
R248	302-473	47 k	½ w				
R249	302-822	8.2 k	½ w				
R250	302-272	2.7 k	½ w				
R254	316-0106-00	10 meg	¼ w				X5490-up
R260A	*312-567	404 k	½ w		Prec	¼%	
R260B	*312-568	606 k	½ w		Prec	¼%	
R260C	*312-571	1.01 meg	½ w		Prec	¼%	
R260D	*312-575	4.04 meg	½ w		Prec	¼%	
R260E	*312-576	6.06 meg	½ w		Prec	¼%	
R260F	*312-577	10.1 meg	½ w		Prec	¼%	
R264	306-224	220 k	2 w				
R267	302-155	1.5 meg	½ w				
R268	302-104	100 k	½ w				
R271	302-101	100 Ω	½ w				
R272	301-822	8.2 k	½ w			5%	
R273	311-326	10 k		Var	MIN SWEEP LENGTH		
R274	305-153	15 k	2 w			5%	
R276	311-016	10 k		Var	LENGTH		
R277	Use 311-110	100 k		Var	MAX SWEEP LENGTH		100-6189
R277	311-0387-00	5 k		Var	MAX SWEEP LENGTH		6190-up
R278	301-393	39 k	½ w			5%	100-6189
R278	305-0912-00	9.1 k	2 w			5%	6190-up
R279	303-123	12 k	1 w			5%	100-6189X
R280	302-125	1.2 meg	½ w				
R281	302-475	4.7 meg	½ w				
R282	302-102	1 k	½ w				
R283	302-102	1 k	½ w				
R291	302-101	100 Ω	½ w				
R293	306-823	82 k	2 w				
R295	302-393	39 k	½ w				
R296	302-104	100 k	½ w				
R297	302-101	100 Ω	½ w				
R299	302-103	10 k	½ w				
R300	302-470	47 Ω	½ w				
R301C	323-611	900 k	½ w		Prec	1%	
R301E	323-610	111 k	½ w		Prec	1%	

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R303	302-105	1 meg	½ w				
R306	316-0223-00	22 k	¼ w				X8590-up
R307	301-0514-00	510 k	½ w			5%	X8590-up
R308	316-0334-00	330 k	¼ w				X8590-up
R311	302-102	1 k	½ w				
R313	306-333	33 k	2 w				
R314	Use 311-0571-00	15 k		Var		VARIABLE 10-1	
R315	306-333	33 k	2 w				
R317	311-026	100 k		Var		EXT HORIZ DC BAL	
R319	302-224	220 k	½ w				
R320	302-332	3.3 k	½ w				
R321	302-101	100 Ω	½ w				
R324	306-273	27 k	2 w				
R330	309-017	1.5 meg	½ w		Prec	1%	
R332	309-086	3.5 meg	½ w		Prec	1%	
R333†	311-149	100 k		Var		HORIZONTAL POSITION	
R336	309-268	12.1 meg	½ w		Prec	1%	100-5489
R336	310-0069-00	13 meg	1 w		Prec	2%	5490-11279
R336	301-0625-00	6.2 meg	½ w			5%	11280-up
R337	301-0685-00	6.8 meg	½ w			5%	X11280-up
R338†	311-149	200 k		Var		VERNIER	
R340	302-222	2.2 k	½ w				
R341	302-101	100 Ω	½ w				
R345	304-104	100 k	1 w				
R347	302-104	100 k	½ w				
R348	311-125	50 k	0.2 w	Var		SWP CAL	
R349	323-408	174 k	½ w		Prec	1%	
R351	302-101	100 Ω	½ w				
R353	304-104	100 k	1 w				
R355	324-443	402 k	1 w		Prec	1%	
R356	324-443	402 k	1 w		Prec	1%	
R357	304-223	22 k	1 w				
R358	311-018	20 k		Var		NORM/MAG REGIS	
R361	302-470	47 Ω	½ w				
R364	*310-506	25 k/6 k	5 w		WW	1%	
R366	302-470	47 Ω	½ w				
R373	305-912	9.1 k	2 w			5%	
R375	311-065	7 k		Var		MAG GAIN	
R376	305-912	9.1 k	2 w			5%	
R377	305-242	2.4 k	2 w			5%	
R380	302-101	100 Ω	½ w				
R381	302-470	47 Ω	½ w				
R384	*310-507	30 k/6 k	5 w		WW	1%	
R386	302-101	100 Ω	½ w				
R387	306-393	39 k	2 w				
R388	306-393	39 k	2 w				
R390	302-222	2.2 k	½ w				
R391	302-470	47 Ω	½ w				
R393	302-391	390 Ω	½ w				
R396	302-474	470 k	½ w				100-8009
R396	301-0474-00	470 k	½ w			5%	8010-up
R397	302-125	1.2 meg	½ w				100-8009
R397	301-0185-00	1.8 meg	½ w			5%	8010-up

†R333 and R338 furnished as a unit.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R398	302-125	1.2 meg	½ w				100-8009
R398	301-0185-00	1.8 meg	½ w			5%	8010-up
R399	302-474	470 k	½ w				100-8009
R399	301-0474-00	470 k	½ w			5%	8010-up
R410	302-105	1 meg	½ w				
R411	302-101	100 Ω	½ w				
R415	302-473	47 k	½ w				
R416	302-123	12 k	½ w				
R421	302-101	100 Ω	½ w				
R424	302-103	10 k	½ w				
R425	302-104	100 k	½ w				
R426	302-473	47 k	½ w				
R427	302-101	100 Ω	½ w				
R428	302-103	10 k	½ w				
R431	308-054	10 k	5 w		WW	5%	
R432	311-015	10 k		Var		DELAY STOP ADJ	
R433	311-022	30 k		Var		DELAY TIME MULTIPLIER 1-10	
R434	302-104	100 k	½ w				
R436	311-141	2 k		Var		DELAY START ADJUST	
R437	308-108	15 k	5 w		WW	5%	
R441	302-101	100 Ω	½ w				
R443	302-272	2.7 k	½ w				
R444	323-385	100 k	½ w		Prec	1%	
R446	323-404	158 k	½ w		Prec	1%	
R447	306-393	39 k	2 w				
R451	302-101	100 Ω	½ w				
R453	302-332	3.3 k	½ w				
R454	302-103	10 k	½ w				
R455	302-274	270 k	½ w				
R456	302-101	100 Ω	½ w				
R457	302-470	47 Ω	½ w				
R458	302-102	1 k	½ w				
R471	304-101	100 Ω	1 w				
R473	302-101	100 Ω	½ w				
R475	302-470	47 Ω	½ w				
R476	302-470	47 Ω	½ w				
R477	302-470	47 Ω	½ w				
R479	302-101	100 Ω	½ w				
R491	316-470	47 Ω	¼ w				
R493	316-470	47 Ω	¼ w				
R494	303-562	5.6 k	1 w			5%	
R495	Use 311-475	5 k	4 w	Var		DC BAL	
R496	303-562	5.6 k	1 w			5%	
R498	316-470	47 Ω	¼ w				
R499	301-622	6.2 k	½ w			5%	
R500	301-622	6.2 k	½ w			5%	
R501	315-154	150 k	¼ w			5%	

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Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R502	311-117	5 k		Var		DC SHIFT	
R504	316-470	47 Ω	¼ w				
R506	302-101	100 Ω	½ w				
R507	Use 301-910	91 Ω	½ w			5%	
R508	305-122	1.2 k	2 w			5%	
R509	323-181	750 Ω	½ w		Prec	1%	
R510	323-239	3.01 k	½ w		Prec	1%	
R511	322-093	90.9 Ω	¼ w		Prec	1%	
R513	315-121	120 Ω	¼ w			5%	
R515	315-270	27 Ω	¼ w			5%	100-6779
R515	315-0300-00	30 Ω	¼ w			5%	6780-up
R516	315-270	27 Ω	¼ w			5%	100-6779
R516	315-0300-00	30 Ω	¼ w			5%	6780-up
R517	308-305	1.3 k	10 w		WW	2%	
R519	Use 315-560	56 Ω	¼ w			5%	100-6779
R519	315-0510-00	51 Ω	¼ w			5%	6780-up
R520	311-246	500 Ω		Var			100-6779
R520	311-0372-00	750 Ω		Var			6780-up
R523	315-121	120 Ω	¼ w			5%	
R525	316-470	47 Ω	¼ w				
R526	322-093	90.9 Ω	¼ w		Prec	1%	
R527	323-239	30.1 k	½ w		Prec	1%	
R530	301-620	62 Ω	½ w			5%	
R532	308-306	3.26 k	3 w		WW	2%	
R533	308-307	5 k	3 w		WW	2%	
R535	302-184	180 k	½ w				
R536	302-123	12 k	½ w				
R537	302-685	6.8 meg	½ w				
R538	302-224	220 k	½ w				
R539	302-104	100 k	½ w				
R541	302-681	680 Ω	½ w				
R543	302-101	100 Ω	½ w				
R544	315-753	75 k	¼ w			5%	
R545	302-820	82 Ω	½ w				100-459
R545	302-0270-00	27 Ω	½w				460-up
R546	302-471	470 Ω	½ w				
R547	308-273	6.5 k	5 w		WW	2%	
R548	302-105	1 meg	½ w				
R549	302-102	1 k	½ w				
R550	315-0153-00	15 k	¼ w			5%	X11150-up
R551	311-0497-00	50 k		Var			X11150-up
R552	302-222	2.2 k	½ w				
R554	323-166	523 Ω	½ w		Prec	1%	
R556	323-137	261 Ω	½ w		Prec	1%	
R557	323-074	57.6 Ω	½ w		Prec	1%	
R560	321-025	17.8 Ω	⅛ w		Prec	1%	100-11149
R560	321-0034-00	22.1 Ω	⅛ W		Prec	1%	11150-up
R561	323-126	200 Ω	½ w		Prec	1%	
R563	315-562	5.6 k	¼ w			5%	
R566	323-137	261 Ω	½ w		Prec	1%	
R567	323-074	57.6 Ω	½ w		Prec	1%	
R569	321-437	348 k	⅛ w		Prec	1%	
R570	321-313	17.8 k	⅛ w		Prec	1%	

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R571	308-289	820 Ω	10 w		WW	5%	
R572	302-820	82 Ω	½ w				
R574	321-013	13.3 Ω	⅛ w		Prec	1%	
R576	321-013	13.3 Ω	⅛ w		Prec	1%	
R577	315-0102-00	1 k	¼ w			5%	X6840-up
R578	315-752	7.5 k	¼ w			5%	100-11149
R578	311-0510-00	10 k		Var			11150-up
R579	315-152	1.5 k	¼ w			5%	
R580	Use 311-0539-00	150 Ω	.25 w	Var		DAMPING	100-11749
R580	311-0970-00	150 Ω		Var		DAMPING	11750-up
R582	315-910	91 Ω	¼ w			5%	
R584	315-470	47 Ω	¼ w			5%	
R585	315-104	100 k	¼ w			5%	
R587	315-101	100 Ω	¼ w			5%	
R589	*310-613	1.1 k	4 w		Prec	2%	
R590	302-820	82 Ω	½ w				
R592	315-910	91 Ω	¼ w			5%	
R594	315-470	47 Ω	¼ w			5%	
R595	315-104	100 k	¼ w			5%	
R596	303-562	5.6 k	1 w			5%	
R597	315-101	100 Ω	¼ w			5%	
R599	*310-613	1.1 k	4 w		Prec	2%	
R601	308-142	30 Ω	3 w		WW	5%	
R602	311-055	50 Ω		Var	WW	SCALE ILLUM	
R604	308-052	6 k	5 w		WW	5%	
R608	302-333	33 k	½ w				
R610	302-104	100 k	½ w				
R615	323-369	68.1 k	½ w		Prec	1%	
R616	311-015	10 k		Var		—150 ADJ	
R617	323-356	49.9 k	½ w		Prec	1%	
R618	302-104	100 k	½ w				
R621	302-102	1 k	½ w				
R623	302-474	470 k	½ w				
R625	302-104	100 k	½ w				
R628	302-275	2.7 meg	½ w				
R629	302-275	2.7 meg	½ w				
R633	302-105	1 meg	½ w				
R635	304-153	15 k	1 w				
R636	304-153	15 k	1 w				
R637	302-154	150 k	½ w				
R638	302-273	27 k	½ w				
R639	302-683	68 k	½ w				
R640	304-100	10 Ω	1 w				
R641	304-100	10 Ω	1 w				
R643	302-102	1 k	½ w				
R644	302-102	1 k	½ w				
R647	308-037	1 k	25 w		WW	5%	
R648	302-100	10 Ω	½ w				

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R650	323-440	374 k	½ w	Prec	1%	
R651	323-675	543 k	½ w	Prec	1%	
R663	302-155	1.5 meg	½ w			
R667	302-684	680 k	½ w			
R668	302-473	47 k	½ w			
R669	302-393	39 k	½ w			
R670	306-100	10 Ω	2 w			
R675	308-147	750 Ω	25 w	WW	5%	
R676	308-037	1 k	25 w	WW	5%	100-8998
R676	308-0102-00	1.25 k	25 w	WW	5%	8999-up
R677	308-155	800 Ω	25 w	WW	5%	
R680	323-440	374 k	½ w	Prec	1%	
R681	323-674	247 k	½ w	Prec	1%	
R682	302-124	120 k	½ w			
R683	302-102	1 k	½ w			
R684	308-0123-00	20 Ω	5 W	WW	5%	X11278-up
R685	304-823	82 k	1 w			
R686	302-184	180 k	½ w			
R687	308-0123-00	20 Ω	5 W	WW	5%	X11278-up
R688	302-155	1.5 meg	½ w			
R689	302-225	2.2 meg	½ w			
R690	302-102	1 k	½ w			
R693	302-155	1.5 meg	½ w			
R697	302-105	1 meg	½ w			
R698	302-274	270 k	½ w			
R699	302-563	56 k	½ w			
R700	306-100	10 Ω	2 w			
R710	324-458	576 k	1 w	Prec	1%	
R711	323-422	243 k	½ w	Prec	1%	
R712	302-154	150 k	½ w			100-11329
R712	302-0105-00	1 meg	½ w			11330-up
R723	302-155	1.5 meg	½ w			
R727	302-105	1 meg	½ w			
R728	302-564	560 k	½ w			
R729	302-473	47 k	½ w			
R730	304-100	10 Ω	1 w			
R731	304-100	10 Ω	1 w			
R732	306-823	82 k	2 w			100-11329X
R736	308-040	1.5 k	25 w	WW	5%	
R740	323-418	221 k	½ w	Prec	1%	
R741	324-467	715 k	1 w	Prec	1%	
R753	302-105	1 meg	½ w			
R757	302-154	150 k	½ w			
R758	302-124	120 k	½ w			
R759	302-273	27 k	½ w			
R760	302-100	10 Ω	½ w			
R767	Use 308-066	4.5 k	5 w	WW	5%	
R778†	311-472	2 x 10 Ω	Var		TRACE ROTATION	
R780	302-154	150 k	½ w			

†Furnished as a unit with R864.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description				S/N Range
R785	302-104	100 k	½ w				
R802	306-271	270 Ω	2 w				
R803	306-563	56 k	2 w				
R804	316-0104-00	100 k	¼ w				X6780-up
R806	Use 302-0823-00	82 k	½ w				
R807	301-432	4.3 k	½ w			5%	
R814	302-474	470 k	½ w				
R820	302-333	33 k	½ w				
R821	301-225	2.2 meg	½ w			5%	
R822	302-333	33 k	½ w				
R823	302-102	1 k	½ w				
R824	305-755	7.5 meg	2 w			5%	
R825	305-755	7.5 meg	2 w			5%	
R826	311-041	1 meg		Var		INTENSITY	100-8989
R826	311-0041-02	1 meg		Var		INTENSITY	8990-up
R827	302-333	33 k	½ w				
R830	302-335	3.3 meg	½ w				
R836	316-105	1 meg	¼ w				
R840	311-034	500 k		Var		HIGH VOLTAGE	
R841	303-205	2 meg	1 w			5%	
R842	303-225	2.2 meg	1 w			5%	
R843	303-225	2.2 meg	1 w			5%	
R845	303-335	3.3 meg	1 w			5%	
R846	311-121	5 meg		Var		FOCUS	100-8989
R846	311-0121-01	5 meg		Var		FOCUS	8990-up
R847	301-364	360 k	½ w			5%	
R853	302-103	10 k	½ w				
R857	302-273	27 k	½ w				
R858	302-105	1 meg	½ w				
R859	302-471	470 Ω	½ w				
R861	311-026	100 k		Var		GEOMETRY	
R862	323-391	115 k	½ w		Prec	1%	
R863	323-394	124 k	½ w		Prec	1%	
R864†	311-472	100 k				ASTIGMATISM	
R865	301-433	43 k	½ w	Var		5%	
R870	301-154	150 k	½ w			5%	
R871	301-245	2.4 meg	½ w			5%	
R872	302-102	1 k	½ w				
R874	301-395	3.9 meg	½ w			5%	
R875	301-683	68 k	½ w			5%	
R876	302-102	1 k	½ w				
R878	304-333	33 k	1 w				
R879	311-016	10 k		Var		CAL ADJ	
R880	302-104	100 k	½ w				
R883	302-101	100 Ω	½ w				
R885	323-673	9.5 k	½ w		Prec	1%	100-6259
R885	323-0673-01	9.5 k	½ w		Prec	½%	6260-up
R886	323-672	6.375 k	½ w		Prec	1%	100-6259
R886	323-0672-01	6.375 k	½ w		Prec	½%	6260-up
R887	323-224	2.1 k	½ w		Prec	1%	100-6259
R887	323-0224-01	2.1 k	½ w		Prec	½%	6260-up

†Furnished as a unit with R778.

Resistors *(Cont'd)*

Ckt. No.	Tektronix Part No.		Description			S/N Range
R888	323-664	1.025 k	½ w	Prec	1%	100-6259
R888	323-0664-01	1.025 k	½ w	Prec	½%	6260-up
R889	323-671	610 Ω	½ w	Prec	1%	100-6259
R889	323-0671-01	610 Ω	½ w	Prec	½%	6260-up
R890	323-126	200 Ω	½ w	Prec	1%	100-6259
R890	323-0126-01	200 Ω	½ w	Prec	½%	6260-up
R891	323-097	100 Ω	½ w	Prec	1%	100-6259
R891	323-0097-03	100 Ω	½ w	Prec	¼%	6260-up
R892	323-606	60 Ω	½ w	Prec	1%	100-6259
R892	323-0606-01	60 Ω	½ w	Prec	½%	6260-up
R893	323-605	40 Ω	½ w	Prec	1%	100-6259
R893	323-0605-01	40 Ω	½ w	Prec	½%	6260-up
R896	323-385	100 k	½ w	Prec	1%	100-6259
R896	323-0385-03	100 k	½ w	Prec	¼%	6260-up
R897	323-097	100 Ω	½ w	Prec	1%	100-6259
R897	323-0097-03	100 Ω	½ w	Prec	¼%	6260-up
R898	323-097	100 Ω	½ w	Prec	1%	100-6259
R898	323-0097-03	100 Ω	½ w	Prec	¼%	6260-up
R899	*308-090	0.25 Ω	1 w	WW		

Switches

	Unwired	Wired			
SW10A SW10B	260-619	*262-657	Rotary	TRIGGER SLOPE TRIGGERING MODE	TIME BASE A
SW60A SW60B	260-261	*262-658	Rotary	TRIGGER SLOPE TRIGGERING MODE	TIME BASE B
SW103	260-017		Push	RESET	
SW110†	311-096			PRESET (Time Base A)	
SW160††	260-230	*262-245	Rotary	TIME/CM A	100-6189
SW160††	260-0230-00	*262-0245-01	Rotory	TIME/CM A	6190-up
SW160Y†††	311-108				
SW210††††	311-096			PRESET (Time Base B)	
SW260	260-260	*262-208	Rotary	TIME/CM B	100-6189
SW260	260-0260-00	*262-0208-01	Rotory	TIME/CM B	6190-up
SW301	260-502	*262-655	Rotary	HORIZONTAL DISPLAY (Front)	
SW347A SW347B	260-503	*262-656	Rotary	HORIZONTAL DISPLAY (Rear) 5 X MAGNIFIER	
SW601	260-199		Toggle	POWER ON	100-8879
SW601	260-0785-00		Toggle	POWER ON	8880-up
SW602†††††					X8880-up
SW858	260-209		Toggle	CRT CATHODE SELECTOR	
SW870	260-253	*262-654	Rotary	AMPLITUDE CALIBRATOR	
TK601	260-618		Thermal Cutout 140° F ±5° F		

†Furnished as a unit with R17 and R110.

††Concentric with SW160Y and R160Y.

†††Furnished as a unit with R160Y.

††††Furnished as a unit with R67 and R210.

†††††See Mechanical Parts List. Line Voltage Selector Body.

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Transformers

Ckt. No.	Tektronix Part No.	Description	S/N Range
T500	276-541	Core, Ferrite	
T555	*120-132	Toroid, 3T Bifilar	
T601	*120-344	L.V. Power	100-8879
T601	*120-0520-00	L.V. Power	8880-up
T801	*120-308	H.V. Power	

Electron Tubes

V24	154-187	6DJ8		100-6729
V24	*157-0122-00	6DJ8	Checked	6730-8879
V24	*157-0125-00	6DJ8	Checked	8880-up
V74	154-187	6DJ8		100-6729
V74	*157-0122-00	6DJ8	Checked	6730-8879
V74	*157-0125-00	6DJ8	Checked	8880-up
V114	154-022	6AU6		
V125	154-022	6AU6		
V133	154-187	6DJ8		
V135	154-187	6DJ8		
V145	154-047	12BY7		
V152	Use *157-0104-02	6AL5	Selected	100-4869
V152	154-0016-00	6AL5		4870-up
V154	154-187	6DJ8		
V161	154-031	6CL6		
V173	154-187	6DJ8		
V183	154-187	6DJ8		
V193	154-187	6DJ8		
V233	154-187	6DJ8		
V235	154-187	6DJ8		
V245	154-022	6AU6		
V252	*157-075	12AL5	Checked	100-4869
V252	154-0038-00	12AL5		4870-up
V261	154-040	12AU6		100-4529
V261	154-0040-05	8426		4530-up
V283	154-187	6DJ8		
V293	154-187	6DJ8		
V314	154-187	6DJ8		
V343	154-187	6DJ8		
V364	154-187	6DJ8		
V384	154-187	6DJ8		
V398	154-031	6CL6		
V414	154-022	6AU6		
V424	154-022	6AU6		
V428	154-187	6DJ8		
V445	154-187	6DJ8		
V494	154-187	6DJ8		100-6729
V494	*157-0122-00	6DJ8	Checked	6730-8879
V494	*157-0125-00	6DJ8	Checked	8880-up
V514	154-340	7119		
V584	154-420	7788		
V594	154-420	7788		
V609	154-052	5651		

Electron Tubes *(Cont'd)*

Ckt. No.	Tektronix Part No.	Description	S/N Range
V624	154-043	12AX7	
V627	154-044	12B4	
V634	154-022	6AU6	
V637	154-044	12B4	
V647	154-044	12B4	
V664	154-022	6AU6	
V677	154-056	6080	
V684	154-043	12AX7	
V694	154-022	6AU6	
V724	154-022	6AU6	
V737	154-056	6080	
V754	154-022	6AU6	
V767	154-044	12B4	
V800	154-021	6AU5	
V814	154-041	12AU7	
V822	154-051	5642	
V832	154-051	5642	
V842	154-051	5642	
V852	154-051	5642	
V859†	Use *154-0478-00	T5470-31-2 Crt Standard Phosphor	100-409
V859	*154-0478-00	T5470-31-2 Crt Standard Phosphor	410-10,999
V859	*154-0568-00	T5471-31-2 Crt Standard Phosphor	11,000-up
V862	154-051	5642	
V875	154-022	6AU6	
V885	154-041	12AU7	

† S/N 100-409 add *050-0246-00 kit.

©

SECTION 7
MECHANICAL PARTS LIST

PARTS ORDERING INFORMATION

Replacement parts are available from or through your local Tektronix Field Office.

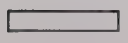
Changes to Tektronix instruments are sometimes made to accommodate improved components as they become available, and to give you the benefit of the latest circuit improvements developed in our engineering department. It is therefore important, when ordering parts, to include the following information in your order: Part number including any suffix, instrument type, serial number, and modification number if applicable.

If a part you have ordered has been replaced with a new or improved part, your local Tektronix Field Office will contact you concerning any change in part number.

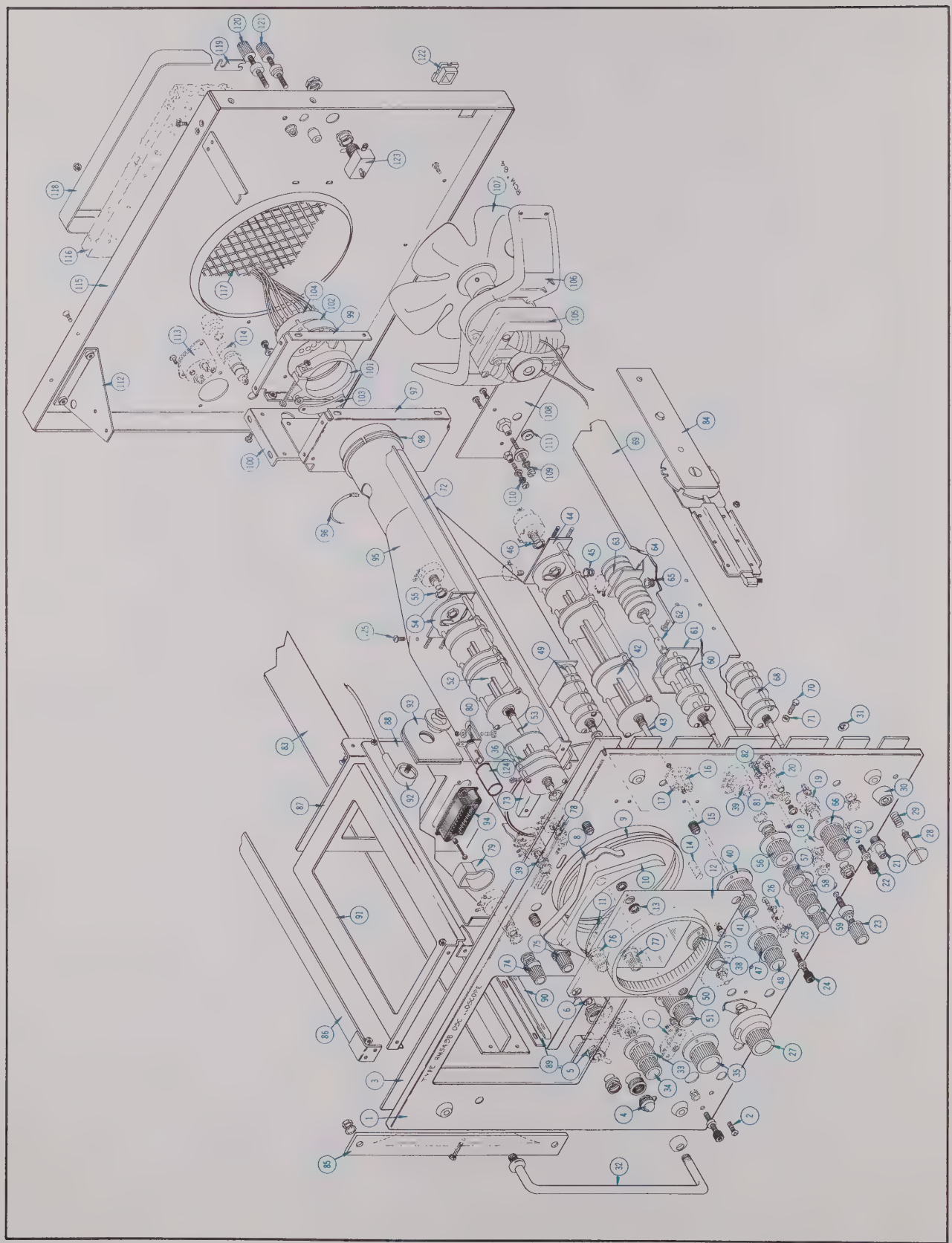
ABBREVIATIONS AND SYMBOLS

a or amp	amperes
BHS	binding head steel
C	carbon
cer	ceramic
cm	centimeter
comp	composition
cps	cycles per second
crt	cathode-ray tube
CSK	counter sunk
dia	diameter
div	division
EMC	electrolytic, metal cased
EMT	electroyltic, metal tubular
ext	external
f	farad
F & I	focus and intensity
FHS	flat head steel
Fil HS	fillister head steel
g or G	giga, or 10^9
Ge	germanium
GMV	guaranteed minimum value
h	henry
hex	hexagonal
HHS	hex head steel
HSS	hex socket steel
HV	high voltage
ID	inside diameter
incd	incandescent
int	internal
k or K	kilohms or kilo (10^3)
kc	kilocycle
m	milli, or 10^{-3}
mc	megacycle
mm	millimeter
meg or M	megohms or mega (10^6)
met.	metal
μ	micro, or 10^{-6}
n	nano, or 10^{-9}
Ω	ohm
OD	outside diameter
OHS	oval head steel
p	pico, or 10^{-12}
PHS	pan head steel
piv	peak inverse voltage
plstc	plastic
PMC	paper, metal cased
poly	polystyrene
Prec	precision
PT	paper tubular
PTM	paper or plastic, tubular, molded
RHS	round head steel
rms	root mean square
sec	second
Si	silicon
S/N	serial number
t or T	tera, or 10^{12}
TD	toroid
THS	truss head steel
tub.	tubular
v or V	volt
Var	variable
w	watt
w/	with
w/o	without
WW	wire-wound

SPECIAL NOTES AND SYMBOLS

X000	Part first added at this serial number.
000X	Part removed after this serial number.
*000-000	Asterisk preceding Tektronix Part Number indicates manufactured by or for Tektronix, or reworked or checked components.
Use 000-000	Part number indicated is direct replacement.
	Internal screwdriver adjustment.
	Front-panel adjustment or connector.

FRONT & REAR



FRONT & REAR

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	333-0845-00			1	PANEL, front RM545B
	- - - - - -			-	Mounting Hardware: (not included)
2	212-0039-00			1	SCREW, 8-32 x 3/8 inch THS
3	387-0971-00			1	PLATE, sub-panel, front
4	378-0518-00	100	8149	1	JEWEL, light, red
	378-0513-00	8150		1	JEWEL, light, green
5	260-0199-00	100	8869	1	SWITCH, unwired—POWER ON
	260-0785-00	8870		1	SWITCH, unwired—POWER ON
	- - - - - -			-	Mounting Hardware: (not included)
	210-0414-00			1	NUT, hex, 15/32-32 x 9/16 inch
	210-0473-00			1	NUT, switch, 15/32-32 x 5/64 inch, 12 sided
	210-0902-00			1	WASHER, .470 ID x 21/32 inch OD
	354-0055-00			1	RING, locking switch
6	136-0025-00			1	SOCKET, light
7	131-0279-00			1	CONNECTOR, chassis mounted, BNC
	- - - - - -			-	Mounting Hardware: (not included)
	210-0004-00			2	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch
	210-0812-00			2	WASHER, fiber, #10
	210-0961-00			1	WASHER, plastic, 13/16 OD x 3/8 inch ID
	211-0025-00			2	SCREW, 4-40 x 3/8 inch FHS 100°
	406-0244-00			1	BRACKET, nylon, 3/4 x 1 3/8 inch insulator
8	214-0433-00	100	409	1	SPRING, light reflector
	354-0262-00	410	10999	1	RING, light plate reflector
	378-0544-00	11000		1	REFLECTOR, light plate
9	354-0204-00	100	10999	1	RING, crt shockmount
	354-0321-00	11000		1	RING, crt shockmount
10	387-0917-00	100	409	1	PLATE, light reflector
	386-0212-00	410	10999	1	PLATE, light reflector
	386-1459-00	11000		1	PLATE, light conductor
	331-0191-01	X11000		1	MASK, graticule (not shown)
11	- - - - - -			1	FILTER, light (see standard accessories)
12	200-0382-00	100	10999	1	COVER, graticule
	200-0896-02	11000		1	COVER, graticule
	- - - - - -			-	Includes:
	354-0116-00			1	RING, ornamental
	- - - - - -			-	Mounting Hardware: (not included)
	210-0816-00			4	WASHER, rubber
13	210-0424-00			4	NUT, knurled, 3/8-24 x 9/16 inch
14	385-0135-00			1	ROD, delrin, 5/16 x 15/16 inch
	- - - - - -			-	Mounting Hardware: (not included)
	213-0068-00			1	SCREW, thread forming, 6-32 x 5/16 inch FHS
15	355-0043-00			4	STUD, graticule
	- - - - - -			-	Each Includes:
	210-0010-00			1	LOCKWASHER, internal, #10
	212-0507-00			1	SCREW, 10-32 x 3/8 inch BHS
16	352-0064-00			3	HOLDER, double neon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch
	211-0109-00			1	SCREW, 4-40 x 7/8 inch FHS
17	378-0541-00			9	FILTER, lens, neon light
18	352-0067-00			3	HOLDER, neon single
	- - - - - -			-	Mounting Hardware For Each: (not included)
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch
	211-0109-00			1	SCREW, 4-40 x 7/8 inch FHS

FRONT & REAR *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
19	260-0017-00			1	SWITCH, unwired—RESET
	- - - - - -			-	Mounting Hardware: (not included)
	210-0207-00			1	LUG, solder, plain
	210-0413-00			2	NUT, hex, 3/8-32 x 1/2 inch
	210-0840-00			1	WASHER, .390 ID x 9/16 inch OD
20	- - - - - -			-	Mounting Hardware For Each Pot:
	210-0046-00			1	LOCKWASHER, internal, 1/4 inch
	210-0223-00			1	LUG, solder, 1/4 inch
	210-0471-00			1	NUT, hex, 1/4-32 x 5/16 x 19/32 inch long
	358-0054-00			1	BUSHING, banana jack, 1/4-32 x 13/32 inch
21	131-0126-00			2	CONNECTOR, coax., single contact, BNC
22	129-0035-00			3	POST, binding assembly
	- - - - - -			-	Each Consisting Of:
	200-0103-00			1	CAP, knurled
	210-0011-00			1	LOCKWASHER, internal, 1/4 inch
	210-0455-00			1	NUT, hex, 1/4-32 x 3/8 x 3/32 inch
	355-0507-00			1	STEM
23	129-0063-00			6	POST, binding
	- - - - - -			-	Mounting Hardware For Each: (not included)
	220-0410-00			1	NUT, keps, 10-32 x 3/8 inch
	358-0169-00			1	BUSHING, nylon
24	200-0103-00			1	CAP, knurled
	355-0507-00			1	STEM, binding post
	- - - - - -			-	Mounting Hardware: (not included)
	210-0223-00			1	LUG, solder, 1/4 inch
25	385-0142-00			1	ROD, hex, 3/8 x 5/8 inch
26	343-0004-00			1	CLAMP, cable, 5/16 inch plastic
	- - - - - -			-	Mounting Hardware: (not included)
	210-0803-00			1	WASHER, 6L x 3/8 inch flat
	211-0504-00			1	SCREW, 6-32 x 1/4 inch BHS
27	331-0091-00			1	DIAL, duo-dial charcoal knob
28	213-0130-00			4	SCREW, captive
29	214-0427-00			4	SPRING, cabinet latch
30	200-0575-00			4	COVER, cabinet latch
31	354-0236-00	100	5089	4	RING, retaining
	354-0294-00	5090		4	RING, retaining
32	367-0041-00			2	HANDLE, assembly
	- - - - - -			-	Each Includes:
	210-0524-00			2	NUT, hex, 5/16-24 x 1/2 inch OD
	210-0807-00			2	WASHER, 5/16 ID x 5/8 inch OD
	367-0003-00			2	HANDLE
	432-0004-00			2	BASE, 3/4 OD x 1/4 inch
33	366-0160-00			1	KNOB, charcoal—HORIZONTAL POSITION
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
34	366-0038-00			1	KNOB, red—VERNIER
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS

FRONT & REAR *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
35	366-0115-00			1	KNOB, charcoal—AMPLITUDE CALIBRATOR
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
36	262-0264-00			1	SWITCH, wired—AMPLITUDE CALIBRATOR
	- - - - - -			-	Includes:
	260-0253-00			1	SWITCH, unwired—AMPLITUDE CALIBRATOR
	210-0207-00			1	LUG, solder, plain, 3/8 inch
	- - - - - -			-	Mounting Hardware for Switch:
	210-0012-00			1	LOCKWASHER, internal, 13/8 x 1/2 inch
	210-0413-00			1	NUT, hex, 3/8-32 x 1/2 inch
37	366-0159-00			1	KNOB, charcoal—TRIGGERING LEVEL "B"
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
38	366-0039-00			1	KNOB, red—STABILITY "B"
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
39	- - - - - -			1	Mounting Hardware For Pot:
	210-0013-00			1	LOCKWASHER, internal, 13/8 x 11/16 inch
	210-0413-00			1	NUT, hex, 3/8-32 x 1/2 inch
40	366-0144-00			1	KNOB, charcoal—TIME/CM "A"
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/15 inch HSS
41	366-0038-00			1	KNOB, red—VARIABLE "A"
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
42	262-0245-00	100	6189	1	SWITCH, wired—TIME/CM "A"
	262-0245-01	6190		1	SWITCH, wired—TIME/CM "A"
	- - - - - -			-	Includes:
	260-0230-00			1	SWITCH, unwired—TIME/CM "A"
	210-0449-00			2	NUT, hex, 5-40 x 1/4 inch
	376-0014-00			1	COUPLING, pot wired steel
43	384-0162-00			1	ROD, extension, 1/8 x 87/16 inches
44	406-0449-00			1	BRACKET, switch
	- - - - - -			-	Mounting Hardware: (not included)
	210-0202-00			1	LUG, solder, SE #6 with 2 wire holes
	210-0203-00			1	LUG, solder, SE #6 long
	210-0407-00			2	NUT, hex, 3/8-32 x 1/2 inch
45	- - - - - -			-	Mini Pot Mounting Hardware: (not included)
	210-0046-00			1	LOCKWASHER, internal, 1/4 inch
	210-0583-00			1	NUT, hex, 1/4-32 x 5/16 inch
46	- - - - - -			-	Pot Mounting Hardware: (not included)
	210-0012-00			1	LOCKWASHER, internal, 13/8 x 1/2 inch
	210-0413-00			2	NUT, hex, 3/8-32 x 1/2 inch
	- - - - - -			-	Mounting Hardware For Switch:
	210-0012-00			1	LOCKWASHER, internal, 13/8 x 1/2 inch
	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
	210-0413-00			1	NUT, hex, 3/8-32 x 1/2 inch
	210-0803-00			4	WASHER, 6L x 3/8 inch flat

FRONT & REAR *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
47	366-0160-00			1	KNOB, charcoal—TRIGGER SLOPE "B"
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
48	366-0038-00			1	KNOB, charcoal—TRIGGERING MODE "B"
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
49	262-0658-00			1	SWITCH, wired—TRIGGER "B"
	- - - - - -			-	Includes:
	260-0261-00			1	SWITCH, unwired—TRIGGER "B"
	- - - - - -			-	Mounting Hardware For Switch:
	210-0013-00			1	LOCKWASHER, internal, 3/8 x 11/16 inch
	210-0413-00			1	NUT, hex, 3/8-32 x 1/2 inch
50	366-0144-00			1	KNOB, charcoal—TIME/CM or DELAY TIME "B"
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set 6-32 x 3/16 inch HSS
51	366-0038-00			1	KNOB, red—STABILITY
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
52	262-0208-00	100	6189	1	SWITCH, wired—TIME/CM or DELAY TIME "B"
	262-0208-01	6190		1	SWITCH, wired—TIME/CM or DELAY TIME "B"
	- - - - - -			-	Includes:
	260-0260-00			1	SWITCH, unwired—TIME/CM or DELAY TIME "B"
	376-0014-00			1	COUPLING, pot wired steel
53	384-0180-00			1	ROD, extension, 1/8 x 5 5/8 inches
54	406-0497-00			1	BRACKET, switch
	- - - - - -			-	Mounting hardware: (not included)
	210-0017-00			2	LOCKWASHER, spring, #5
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
55	- - - - - -			-	Pot Mounting Hardware: (not included)
	210-0012-00			1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-0413-00			2	NUT, , 13/8-32 x 1/2 inch
56	366-0159-00			1	KNOB, charcoal—TRIGGERING LEVEL "A"
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
57	366-0039-00			1	KNOB, red—STABILITY "A"
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set 6-32 3/16 inch HSS
58	366-0160-00			1	KNOB, charcoal—HORIZONTAL DISPLAY
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
59	366-0038-00			1	KNOB, red—5X MAGNIFIER
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 3/16 inch HSS
60	262-0655-00			1	SWITCH, wired—HORIZONTAL DISPLAY (front)
	- - - - - -			-	Includes:
	260-0502-00			1	SWITCH, unwired—HORIZONTAL DISPLAY (front)

FRONT & REAR *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
61	337-279			1	SHIELD, switch
	- - - -			-	Mounting Hardware: (not included)
	210-004			1	LOCKWASHER, internal, #4
	210-201			1	LUG, solder, SE #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	211-007			2	SCREW, 4-40 x 3/16 inch BHS
	- - - -			-	Mounting Hardware For Switch:
	210-013			1	LOCKWASHER, internal, 3/8 x 11/16 inch
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
62	376-007			1	COUPLING, shaft, 1 inch long
63	262-656			1	SWITCH, wired — HORIZONTAL DISPLAY (rear)
	- - - -			-	Includes:
	260-503			1	SWITCH, unwired — HORIZONTAL DISPLAY (rear)
64	406-450			1	BRACKET, mag. switch
	- - - -			-	Mounting Hardware: (not included)
	210-004			2	LOCKWASHER, internal, #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	211-013			2	SCREW, 4-40 x 1/4 inch BHS
	- - - -			-	Mounting Hardware For Capacitor:
	210-004			2	LOCKWASHER, internal, #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	211-008			2	SCREW, 4-40 x 1/4 inch BHS
65	- - - -			-	Mounting Hardware For Pot:
	210-046			1	LOCKWASHER, internal, 1/4 inch
	210-583			1	NUT, hex, 1/4-32 x 5/16 inch
	- - - -			-	Mounting Hardware For Switch:
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-840			1	WASHER, .390 ID x 9/16 inch OD
	210-012			1	LOCKWASHER, internal, 3/8 x 1/2 inch
66	366-160			1	KNOB, charcoal — TRIGGER SLOPE "A"
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
67	366-038			1	KNOB, charcoal — TRIGGERING MODE "A"
	- - - -			-	Includes:
	213-004			1	SCREW, set, 6-32 x 3/16 inch HSS
68	262-657			1	SWITCH, wired — TRIGGER "A"
	- - - -			-	Includes:
	260-619			1	SWITCH, unwired — TRIGGER "A"
	- - - -			-	Mounting Hardware For Switch:
	210-013			1	LOCKWASHER, internal, 3/8 x 11/16 inch
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
69	351-077			1	GUIDE, rail track support, right
	- - - -			-	Mounting Hardware: (not included)
	212-560			2	SCREW, 10-32 x 5/16 inch FHS 100°
70	213-090			2	SCREW, 10-32 x 1/2 inch HHS
71	361-071			2	SPACER, guide rail, 5/16 inch diameter

FRONT & REAR *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
72	122-0109-00			1	ANGLE, rail, top left
	- - - - - -			-	Mounting Hardware: (not included)
	210-0458-00			6	NUT, keps, 8-32 x 13/32 inch
	212-0040-00			7	SCREW, 8-32 x 3/8 inch FHS 100°
73	407-0002-00			1	BRACKET, rail angle
74	366-0220-00			1	KNOB, charcoal—INTENSITY
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
75	366-0220-00			1	KNOB, charcoal—FOCUS
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
76	366-0254-00			1	KNOB, charcoal—ASTIGMATISM
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
77	366-0220-00			1	KNOB, charcoal—SCALE ILLUM
	- - - - - -			-	Includes:
	213-0004-00			1	SCREW, set, 6-32 x 3/16 inch HSS
78	- - - - - -			-	Pot Mounting Hardware: (not included)
	210-0012-00			1	LOCKWASHER, internal, 3/8 x 1/2 inch
	210-0207-00			1	LUG, solder, plain, 3/8 inch
	210-0413-00			1	NUT, hex, 3/8-32 x 1/2 inch
79	200-0269-00	100	8989	2	COVER, pot
	200-0745-00	8990		2	COVER, pot
80	136-0001-00			2	SOCKET, graticule lamp
	- - - - - -			-	Mounting Hardware For Each: (not included)
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
	210-0803-00			1	WASHER, 6L x 3/8 inch flat
	211-0534-00			1	SCREW, 6-32 x 5/16 inch PHS with lockwasher
81	384-0527-00			1	ROD, spacing, 3/8 x 3 inches
	- - - - - -			-	Mounting Hardware: (not included)
	210-0007-00			1	LOCKWASHER, external, #8
	212-0040-00			1	SCREW, 8-32 x 3/8 inch FHS 100°
82	343-0013-00			1	CLAMP, cable, 3/8 inch plastic
	- - - - - -			-	Mounting Hardware: (not included)
	210-0804-00			1	WASHER, 8S x 3/8 inch flat
	212-0004-00			1	SCREW, 8-32 x 5/16 inch BHS
83	351-0075-00			1	GUIDE, rail track support, left
	- - - - - -			-	Mounting Hardware: (not included)
	212-0560-00			2	SCREW, 10-32 x 5/16 inch FHS 100°
	213-0090-00			2	SCREW, 10-32 x 1/2 inch HHS
	361-0071-00			2	SPACER, guide rail, 5/16 inch
84	351-0007-00			2	TRACK, chassis slide-out
	- - - - - -			-	Mounting Hardware: (not included w/track)
	212-0023-00	X390		12	SCREW, 8-32 x 3/8 inch BHS
85	122-0119-00			2	ANGLE, brace, guide rail
86	122-0120-00			3	ANGLE, rail corner
	- - - - - -			-	Mounting Hardware For Each: (not included)
	210-0458-00			3	NUT, keps, 8-32 x 11/32 inch
	212-0040-00			2	SCREW, 8-32 x 3/8 inch FHS 100°

FRONT & REAR *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
87	387-0855-00			1	PLATE, plug-in housing, back
	- - - - - -			-	Mounting Hardware: (not included)
	210-0458-00			4	NUT, keps, 8-32 x 11/32 inch
	212-0023-00			4	SCREW, 8-32 x 3/8 inch BHS
88	387-0970-00			1	PLATE, plug-in housing, side
	- - - - - -			-	Mounting Hardware: (not included)
	210-0457-00			3	NUT, keps, 6-32 x 5/16 inch
	210-0458-00			2	NUT, keps, 8-32 x 11/16 inch
	211-0559-00			3	SCREW, 6-32 x 3/8 inch FHS
	212-0004-00			3	SCREW, 8-32 x 5/16 inch BHS
89	387-0755-00			1	PLATE, plug-in housing, bottom
	- - - - - -			-	Mounting Hardware: (not included)
	210-0458-00			4	NUT, keps, 8-32 x 11/32 inch
	212-0023-00			2	SCREW, 8-32 x 3/8 inch BHS
	212-0040-00			2	SCREW, 8-32 x 3/8 inch FHS 100°
90	351-0058-00			4	GUIDE, shoe
91	387-0857-00			1	PLATE, plug-in housing, top
	- - - - - -			-	Mounting Hardware: (not included)
	210-0458-00			2	NUT, keps, 8-32 x 11/32 inch
	212-0040-00			2	SCREW, 8-32 x 3/8 inch FHS 100°
	344-0097-00			2	CLIP, grounding
92	131-0350-00			1	CONNECTOR, crt anode
	- - - - - -			-	Includes:
	200-0110-00			1	CAP, crt anode
	214-0357-00			1	SPRING, crt anode connector
	432-0046-00			1	BASE, crt anode connector
93	200-0112-00			1	COVER, crt anode and plate assembly
	- - - - - -			-	Consisting Of:
	200-0111-00			1	COVER, crt anode
	386-0647-00			1	PLATE, crt anode
94	131-0018-00			1	CONNECTOR, 16 pin female
	- - - - - -			-	Mounting Hardware: (not included)
	166-0107-00	100	3419	2	TUBE, spacer, 1/4 OD x 7/32 inch
	166-0030-00	3420		2	TUBE, spacer, 1/4 OD x 3/16 inch
	210-0004-00			2	LOCKWASHER, internal, #4
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch
	211-0016-00			2	SCREW, 4-40 x 5/8 inch RHS
95	337-0620-00			1	SHIELD, cathode ray tube
	- - - - - -			-	Mounting Hardware: (not included)
	211-0504-00			4	SCREW, 6-32 x 1/4 inch BHS
96	175-0592-00			1	WIRE, crt, with connector, striped orange
	175-0595-00			1	WIRE, crt, with connector, striped red
	175-0641-00			1	WIRE, crt, with connector, striped brown
	175-0642-00			1	WIRE, crt, with connector, striped blue

FRONT & REAR *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
97	407-0004-00			1	BRACKET, crt shield
	- - - - - -			-	Mounting Hardware: (not included)
	210-0458-00			1	NUT, keps, 8-32 x 11/32 inch
	210-0804-00			1	WASHER, 8S x 3/8 inch flat
	212-0004-00			5	SCREW, 8-32 x 5/16 inch BHS
98	252-0547-00			FT	VINYL, extruded channel cushion (8 1/8 inches)
99	406-0994-00			1	BRACKET, crt socket
	- - - - - -			-	Mounting Hardware: (not included)
	210-0458-00			1	NUT, keps, 8-32 x 11/32 inch
	210-0804-00			1	WASHER, 8S x 3/8 inch flat
	212-0004-00			1	SCREW, 8-32 x 5/16 inch BHS
100	406-0995-00			1	BRACKET, support
	- - - - - -			-	Mounting Hardware: (not included)
	212-0004-00			4	SCREW, 8-32 x 5/16 inch BHS
101	354-0215-00			1	RING, crt clamping assembly
	- - - - - -			-	Consisting Of:
102	124-0160-00			1	STRIP, liner, crt clamp
	210-0407-00			1	NUT, hex., 6-32 x 1/4 inch
	211-0560-00			1	SCREW, 6-32 x 1inch RHS
	354-0211-00			1	RING, clamping
103	214-0207-00			1	NUT, adjusting, securing
	- - - - - -			-	Mounting Hardware: (not included)
	210-0949-00			4	WASHER, 9/64 ID x 1/2 inch OD
	211-0576-00			2	SCREW, 6-32 x 7/8 inch, socket head cap
104	136-0191-00			1	SOCKET, crt assembly
	- - - - - -			-	Includes:
	131-0178-00			8	CONNECTOR, crt cable end
	136-0117-00			1	SOCKET, crt, 14 pin
	213-0086-00			2	SCREW, thread forming, 2-32 x 7/16 inch PHS
	387-0393-00			1	PLATE, back, crt socket
105	147-0026-00			1	MOTOR, fan
	- - - - - -			-	Mounting Hardware: (not included)
	210-0458-00			4	NUT, keps, 8-32 x 11/32 inch
106	426-0193-00			1	MOUNT, fan motor
	- - - - - -			-	Mounting Hardware: (not included)
	212-0023-00			4	SCREW, 8-32 x 3/8 inch BHS
107	369-0007-00			1	FAN, blade, 7 inches
108	407-0027-00			1	BRACKET, shunt resistor
	- - - - - -			-	Mounting Hardware: (not included)
	211-0537-00			2	SCREW, 6-32 x 3/8 inch THS
109	- - - - - -			-	Mounting Hardware For Each Resistor:
	210-0008-00			1	LOCKWASHER, internal, #8
	210-0462-00			1	NUT, hex, 8-32 x 1/2 inch
	210-0809-00	100	11159	1	WASHER, centering
	210-0808-00	11160		1	WASHER, centering
	212-0004-00			1	SCREW, 8-32 x 5/16 inch BHS
	212-0037-00			1	SCREW, 8-32 x 1 3/4 inches Fil HS

FRONT & REAR *(Cont'd)*

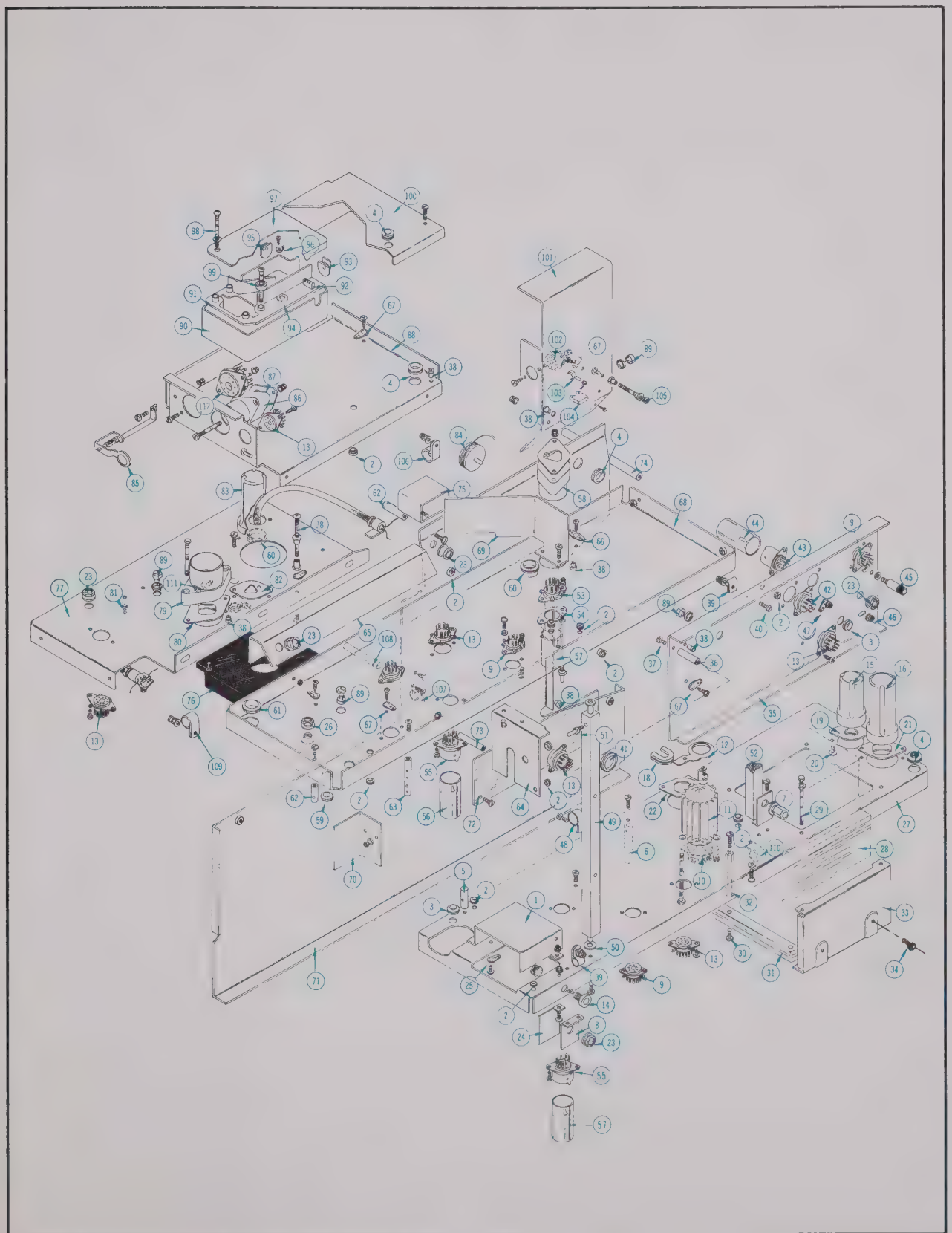
REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
110	- - - - - -			-	Resistor Mounting Hardware:
	211-0507-00			1	SCREW, 6-32 x 5/16 inch BHS
	210-0478-00			1	NUT, hex, 5/16 x 21/32 inch
	210-0805-00	100	219X	1	WASHER, 10S x 7/16 inch flat
	210-0886-00	100	219X	1	WASHER, centering, 3/8 x 1/8 inch
	211-0544-00			1	SCREW, 6-32 x 3/4 inch THS
111	348-0056-00			2	GROMMET, plastic, 3/8 inch
112	406-0963-00			1	BRACKET, vertical amplifier
	- - - - - -			-	Mounting Hardware: (not included)
	212-0039-00			2	SCREW, 8-32 x 3/8 inch THS
113	131-0102-00	100	6264	1	CONNECTOR, chassis mounted, motor base
	131-0102-01	6265	8229	1	CONNECTOR, chassis mounted, motor base
	131-0102-02	8230		1	CONNECTOR, chassis mounted, motor base
	- - - - - -			-	consisting of:
	129-0041-00	100	6264	1	POST, ground
	129-0041-01	6265	8229	1	POST, ground
	200-0185-00	100	6264	1	COVER
	200-0185-01	6265	8229	1	COVER
	204-0335-00	8230		1	BODY-CONTACT ASSEMBLY
	210-0003-00	100	6264X	2	LOCKWASHER, external, #4
	210-0551-00	100	6264X	2	NUT, hex., 4-40 x 1/4 inch
	213-0088-00	X6264	8229	1	SCREW, thread forming, #4 x 1/4 inch, PHS
	213-0146-00	8230		1	SCREW, thread forming, #6 x 0.313 inch, PHS
	211-0132-00	X6264	8229	1	SCREW, sems, 4-40 x 1/2 inch, PHS
	211-0534-00	8230	11769	1	SCREW, sems, 4-40 x 5/16 inch, PHS
	211-0614-00	11770		1	SCREW, sems, 4-40 x 1/4 inch, PHS
	214-0078-00			2	PIN, connecting
	377-0041-00	100	6264	1	INSERT
	377-0051-00	6265	8229	1	INSERT
	214-1016-00	8230		1	INSULATOR, connector
	386-0933-00	100	8239	1	PLATE, mounting
	386-1356-01	8230		1	PLATE, mounting
114	352-0002-00	100	8869X	1	FUSE, 3AG, assembly
	- - - - - -			-	Consisting Of:
	200-0582-00			1	CAP, fuse
	210-0873-00			1	WASHER, rubber, 1/2 ID x 11/16 inch
	352-0010-00			1	HOLDER, fuse
	- - - - - -			1	NUT, fuse holder
	204-0279-00	X8870		1	BODY, line voltage selector
	- - - - - -			-	Mounting Hardware: (not included)
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x 1/4 inch
	200-0762-00	X8870		1	COVER, line voltage selector
	- - - - - -			-	consisting of:
	352-0102-00			2	HOLDER, fuse
	- - - - - -			-	Mounting Hardware For Each: (not included)
	213-0088-00			2	SCREW, thread forming, #4 x 1/4 inch, PHS
	179-1214-00	X8870		1	CABLE HARNESS, line voltage selector
115	387-0955-00	100	8869	1	PLATE, subpanel, rear
	387-0955-02	8870		1	PLATE, subpanel, rear
116	378-0023-00			1	FILTER, air foam
117	378-0762-00			1	FILTER, screen
	- - - - - -			-	Mounting Hardware: (not included)
	213-0104-00			4	SCREW, thread forming, 6-32 x 3/8 inch THS
	214-1000-00	X8870		4	CORNER, filter housing
118	380-0018-00	100	8869	1	HOUSING, air filter
	380-0018-03	8870		1	HOUSING, air filter
	- - - - - -			-	Mounting Hardware: (not included)
	210-0402-00			2	NUT, cap, hex, 8-32 x 5/16 inch
	210-0458-00			2	NUT, keps, 8-32 x 11/32 inch
	212-0031-00			2	SCREW, 8-32 x 1 1/4 inches RHS
119	346-0027-00			1	STRAP, ground

©

FRONT & REAR (Cont'd)

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
120	129-0064-00			1	POST, binding
	- - - - - -			-	Mounting Hardware: (not included)
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
121	129-0064-00			1	POST, binding
	- - - - - -			-	Mounting Hardware: (not included)
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
	358-0181-00			1	BUSHING, nylon, charcoal
122	358-0236-00			2	BUSHING, guide, delrin
123	260-0209-00			1	SWITCH, unwired—CRT CATHODE SELECTOR
	- - - - - -			-	Mounting Hardware: (not included)
	210-0414-00			1	NUT, hex, 15/32 inch
	210-0473-00			1	NUT, switch, 15/32-32 x 5/64 inch
	210-0902-00			1	WASHER, .470 ID x 21/32 inch OD
124	166-0328-00			2	SLEEVE, graticule light
125	- - - - - -			-	Mounting Hardware for coil: (not included)
	211-0589-00	100	409	3	SCREW, 6-32 x 5/16 inch BHB
	211-0596-00	410		3	SCREW, 6-32 x 3/8 inch PHB
	210-0811-00	X410		3	WASHER, fiber, #6
	210-0803-00	X410		3	WASHER, 6L x 3/8 inch
	210-0407-00	100	409	3	NUT, hex, 6-32 x 1/4 inch
	210-0457-00	410		3	NUT, keps, 6-32 x 5/16 inch

CHASSIS



CHASSIS

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	337-0291-99			1	SHIELD, upper calibrator switch
	- - - - - -			-	Mounting Hardware: (not included)
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
	211-0507-00			2	SCREW, 6-32 x 5/16 inch BHS
2	348-0055-00			23	GROMMET, plastic, 1/4 inch
3	348-0056-00			15	GROMMET, plastic, 3/8 inch
4	348-0063-00			6	GROMMET, plastic, 1/2 inch
5	385-0135-00			1	ROD, delrin, 5/16 x 15/16 inch
	- - - - - -			-	Mounting Hardware: (not included)
	213-0041-00			1	SCREW, 6-32 x 3/8 inch THS
6	385-0138-00			1	ROD, delrin, 5/16 x 1 9/16 inches
	- - - - - -			-	Mounting Hardware: (not included)
	213-0041-00			1	SCREW, 6-32 x 3/8 inch THS
7	406-0108-00			1	BRACKET, pot, —150 adj.
	- - - - - -			-	Mounting Hardware: (not included)
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
	211-0507-00			2	SCREW, 6-32 x 5/16 inch BHS
8	406-0022-00			1	BRACKET, pot
	- - - - - -			-	Mounting Hardware: (not included)
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
	211-0507-00			2	SCREW, 6-32 x 5/16 inch BHS
9	136-0008-00			11	SOCKET, STM7G
	- - - - - -			-	Mounting Hardware For Each: (not included)
	213-0044-00			2	SCREW, 5-32 x 3/16 inch PHS
10	136-0011-00			2	SOCKET, STM8G
	- - - - - -			-	Mounting Hardware For Each: (not included)
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
	211-0538-00			2	SCREW, 6-32 x 5/16 inch FHS 100°
11	337-0648-00			2	SHIELD, heat dissipating
12	343-0074-00			2	CLAMP, tube, top hat
13	136-0015-00	100	8189	31	SOCKET, STM9G
	136-0015-00	8190		30	SOCKET, STM9G
	- - - - - -			-	Mounting Hardware For Each: (not included)
	213-0044-00			2	SCREW, 5-32 x 3/16 PHS
14	136-0037-00			1	SOCKET, tip jack
	- - - - - -			-	Mounting Hardware: (not included)
	210-0413-00			1	NUT, hex, 3/8-32 x 1/2 inch
	210-0840-00			1	WASHER, .390 ID x 9/16 inch OD
15	200-0256-00			1	COVER, capacitor, polyethylene, 2 1/32 x 1 inch diameter
16	200-0258-00			3	COVER, capacitor, polyethylene, 3 1/2 x 1.365 inches ID
17	343-0004-00			5	CLAMP, cable, 5/16 inch
	- - - - - -			-	Mounting Hardware For Each: (not included)
	210-0804-00			1	WASHER, 8S x 3/8 inch, flat
	212-0004-00			1	SCREW, 8-32 x 5/16 inch BHS
18	358-0166-00			1	EXTRUSION, rubber, 2 inches

CHASSIS *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
19	386-252			1	PLATE, fiber, small
	- - - -			-	Mounting Hardware: (not included)
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
20	211-534			2	SCREW, 6-32 x 5/16 inch PHS with lockwasher
21	386-254			3	PLATE, fiber, large
	- - - -			-	Mounting Hardware For Each: (not included)
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
	211-543			2	SCREW, 6-32 x 5/16 inch RHS
22	386-255			3	PLATE, metal, large
	- - - -			-	Mounting Hardware For Each: (not included)
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
	211-534			2	SCREW, 6-32 x 5/16 inch PHS with lockwasher
23	- - - -			-	Mounting Hardware For Pot:
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-840			1	WASHER, .390 ID x 9/16 inch OD
24	337-290			1	SHIELD, lower calibrator switch
	- - - -			-	Mounting Hardware: (not included)
	210-457			1	NUT, keps, 6-32 x 5/16 inch
	211-507			1	SCREW, 6-32 x 5/16 inch BHS
25	210-202			5	LUG, solder, SE #6
	- - - -			-	Mounting Hardware For Each: (not included)
	210-006			1	LOCKWASHER, internal, #6
	210-407			1	NUT, hex, 6-32 x 1/4 inch
	211-507			1	SCREW, 6-32 x 5/16 inch BHS
26	- - - -			-	Mounting Hardware For Pot:
	210-413			1	NUT, hex, 3/8-32 x 1/2 inch
	210-840			1	WASHER, .390 ID x 9/16 inch OD
27	441-238			1	CHASSIS power
	- - - -			-	Mounting Hardware: (not included)
	210-458			5	NUT, keps, 8-32 x 11/32 inch
	212-039			2	SCREW, 8-32 x 3/8 inch THS, phillips
	212-040			3	SCREW, 8-32 x 3/8 inch FHS 100°
28	- - - -			-	Transformer Mounting Hardware:
	210-010			4	LOCKWASHER, internal, #10
	210-458			2	NUT, keps, 8-32 x 11/32 inch
	210-564			4	NUT, hex, 10-32 x 3/8 inch
	210-812			4	WASHER, fiber, #10
	212-033			4	SCREW, 8-32 x 3/4 inch BHS
	212-559			2	SCREW, 10-32 x 5/8 inch FHS 100°
29	212-524			4	SCREW, 10-32 x 3 1/4 inches HHS
30	212-534			2	SCREW, 10-32 x 1 inch BHS
31	381-221			2	BAR, transformer support
32	384-612			2	ROD, hex, transformer stand-off
33	407-055			1	BRACKET, transformer
34	212-004			2	SCREW, 8-32 x 5/16 inch BHS

CHASSIS *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
35	441-560			1	CHASSIS, delay sweep
	- - - -			-	Mounting Hardware: (not included)
36	166-143			2	TUBE, spacer, 3/8 x 13/16 inch
37	211-529			2	SCREW, 6-32 x 1 1/4 inches BHS
38	348-031			5	GROMMET, 1/4 inch, plastic
39	343-001			3	CLAMP, cable, 1/8 inch, plastic
	- - - -			-	Mounting Hardware For Each: (not included)
	210-006			1	LOCKWASHER, internal, #6
	210-407			1	NUT, hex, 6-32 x 1/4 inch
	210-803			1	WASHER, 6L x 3/8 inch, flat
40	211-510			1	SCREW, 6-32 x 3/8 inch BHS
41	348-051			1	GROMMET, rubber, 1 1/8 inches
42	136-044			3	SOCKET, 7 pin
	- - - -			-	Mounting Hardware For Each: (not included)
	213-044			2	SCREW, 5-32 x 3/16 inch PHS, phillips
43	136-010			1	SOCKET, 7 pin
	- - - -			-	Mounting Hardware: (not included)
	210-004			2	LOCKWASHER, internal, #4
	210-201			1	LUG, solder, SE #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	211-033			2	SCREW, 4-40 x 5/16 inch PHS with lockwasher
44	337-006			2	SHIELD, tube, 1 3/8 inches high
45	214-008			1	BOLT, captive
	210-812			1	WASHER, fiber, #10
	354-048			1	RING, securing
46	- - - -			-	Mounting Hardware For Miniature Pot:
	210-583			1	NUT, hex, 1/4-32 x 5/16 inch
	210-940			1	WASHER, 1/4 ID x 3/8 inch OD
47	210-202			2	LUG, solder, SE #6
	- - - -			-	Mounting Hardware For Each: (not included)
	213-044			1	SCREW, 5-32 x 3/16 inch PHS, phillips
48	343-004			1	CLAMP, cable, 5/16 inch, plastic
	- - - -			-	Mounting Hardware: (not included)
	210-803			1	WASHER, 6L x 3/8 inch, flat
	211-511			1	SCREW, 6-32 x 1/2 inch BHS
49	381-063			1	BAR, swivel support
	- - - -			-	Mounting Hardware: (not included)
50	210-821			2	WASHER, 1/4 x 1/2 x .046 inch
51	105-014			2	STOP, hex, 1/4 x 3/4 inch
52	381-064			1	BAR, swivel support
	- - - -			-	Mounting Hardware: (not included)
	212-008			2	SCREW, 8-32 x 1/2 inch BHS
53	136-015			12	SOCKET, STM9G
	- - - -			-	Mounting Hardware For Each: (not included)
	210-004			2	LOCKWASHER, internal, #4
	210-406			2	NUT, hex, 4-40 x 3/16 inch
	211-033			2	SCREW, 4-40 x 5/16 inch PHS with lockwasher
54	337-004			2	SHIELD, socket

CHASSIS *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
55	136-0022-00	100	8189	1	SOCKET, STM9S
	136-0022-00	8190		2	SOCKET, STM9S
	- - - - - -			-	Mounting Hardware: (not included)
	213-0044-00			2	SCREW, 5-32 x 3/16 inch PHS
56	337-0009-00			1	SHIELD, tube, 2 13/32 inches high
57	337-0008-00	100	8189	2	SHIELD, tube, 1 15/16 inches high
	337-0008-00	8190		3	SHIELD, tube, 1 15/16 inches high
58	- - - - - -			-	Mounting Hardware For Capacitor:
	432-0047-00			1	BASE, small capacitor mounting
	386-0253-00			1	PLATE, metal, small
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
	211-0514-00			2	SCREW, 6-32 x 3/4 inch BHS
59	348-0003-00			1	GROMMET, rubber, 5/16 inch
60	348-0050-00			2	GROMMET, plastic, 3/4 inch
61	348-0064-00			1	GROMMET, plastic, 5/8 inch
62	385-0033-00			1	ROD, nylon, 5/16 x 5/8 inch
	- - - - - -			-	Mounting Hardware: (not included)
	211-0507-00			1	SCREW, 6-32 x 5/16 inch BHS
63	385-0129-00			2	ROD, nylon, 5/16 x 1 5/8 inches
	- - - - - -			-	Mounting Hardware For Each: (not included)
	213-0041-00			1	SCREW, 6-32 x 3/8 inch THS
64	406-0451-00			1	BRACKET, horizontal display switch
	- - - - - -			-	Mounting Hardware: (not included)
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
	210-0803-00			2	WASHER, 6L x 3/8 inch flat
	211-0510-00			2	SCREW, 6-32 x 3/8 inch BHS
65	406-0454-00			1	BRACKET, pot
	- - - - - -			-	Mounting Hardware: (not included)
	212-0004-00			2	SCREW, 8-32 x 5/16 inch BHS
66	210-0204-00			1	LUG, solder, DE #6
	- - - - - -			-	Mounting Hardware: (not included)
	213-0044-00			1	SCREW, 5-32 x 3/16 inch PHS
67	210-0201-00			7	LUG, solder, SE #4
	- - - - - -			-	Mounting Hardware: (not included)
	213-0044-00			1	SCREW, 5-32 x 3/16 inch PHS
68	411-0559-00			1	CHASSIS, sweep
	- - - - - -			-	Mounting Hardware: (not included)
	210-0458-00			2	NUT, keps, 8-32 x 11/32 inch
	212-0040-00			4	SCREW, 8-32 x 3/8 inch FHS 100°
	670-0569-00	X8590		1	ASSEMBLY, circuit board (not shown)
	- - - - - -			-	assembly includes:
	388-0953-00			1	BOARD, circuit
	214-0506-00			6	PIN, connector
	136-0183-00			1	SOCKET, transistor, 3 pin
	- - - - - -			-	mounting hardware: (not included)
	348-0519-00	X8590		2	ROD, sacing 1/4 x 9/16 inch long
	211-0501-00	X8590		2	SCREW, sems, 6-32 x 0.313 inch, PHS
	211-0534-00	X8590		2	SCREW, sems, 6-32 x 5/16 inch, PHS
69	337-0664-00			1	SHIELD, amp.
	- - - - - -			-	Mounting Hardware: (not included)
	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
	211-0507-00			2	SCREW, 6-32 x 5/16 inch BHS
70	337-0660-00	100	7619	1	SHIELD, trigger switch
	337-0660-01	7620		1	SHIELD, trigger switch
	- - - - - -			-	Mounting Hardware: (not included)
	210-0406-00			2	NUT, hex, 4-40 x 3/16 inch

CHASSIS *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
71	387-0946-00			1	PLATE, rectifier mounting
	- - - - - -			-	Mounting Hardware: (not included)
	210-0458-00			2	NUT, keps, 8-32 x 11/32 inch
	212-0023-00			6	SCREW, 8-32 x 3/8 inch BHS
72	337-0656-00			1	SHIELD, plastic, high voltage
	- - - - - -			-	Mounting Hardware: (not included)
73	166-0099-00			3	SPACER, 1/4 x 1 23/32 inches
	211-0507-00			6	SCREW, 6-32 x 5/16 inch BHS
74	384-0630-00			1	ROD spacing
	- - - - - -			-	Mounting Hardware: (not included)
	212-0004-00			1	SCREW, 8-32 x 5/16 inch BHS
75	202-0102-00			1	CAN, relay cover
	- - - - - -			-	Mounting Hardware: (not included)
	210-0457-00			2	NUT, keps, 6-32 x 5/16 inch
76	119-0034-00			1	DELAY LINE ASSEMBLY
	- - - - - -			-	Includes:
	380-0049-00			1	HOUSING, delay line
	200-0482-00	100	5809	1	COVER, delay line housing
	200-0482-03	5810		1	COVER, delay line housing
	131-0271-00			2	CONNECTOR, right hand
	211-0591-00	100	5779	4	SCREW, 6-32 x 7/8 inch HHS
	211-0516-00	5780		4	SCREW, 6-32 x 7/8 inch, PHS
	211-0006-00			4	LOCKWASHER, internal, #6
	210-0407-00			4	NUT, hex, 6-32 x 1/4 inch
	- - - - - -			-	Mounting Hardware:
	210-0006-00			1	LOCKWASHER, internal, #6
	210-0202-00			2	LUG, solder, SE #6
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
	211-0507-00			2	SCREW, 6-32 x 5/16 inch BHS
77	441-0562-00			1	CHASSIS, vertical amplifier
	- - - - - -			-	Mounting Hardware: (not included)
	212-0023-00			5	SCREW, 8-32 x 3/8 inch BHS
78	- - - - - -			-	Resistor Mounting Hardware:
	210-0202-00			1	LUG, solder, SE #6
	210-0478-00			1	NUT, hex, 5/16 x 21/32 inch
	210-0601-00			1	EYELET, brass, tapered barrel
	211-0553-00			1	SCREW, 6-32 x 1 1/2 inches, THS
	211-0507-00			1	SCREW, 6-32 x 5/16 inch BHS
79	- - - - - -			-	Capacitor Mounting Hardware:
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex, 6-32 x 1/4 inch
	211-0588-00			2	SCREW, 6-32 x 3/4 inch HHS
80	386-0255-00			1	PLATE, metal, large capacitor
	432-0048-00			1	BASE, large capacitor mounting
81	131-0181-00			2	CONNECTOR, terminal stand-off
	- - - - - -			-	Mounting Hardware For Each: (not included)
	358-0136-00			1	BUSHING, teflon

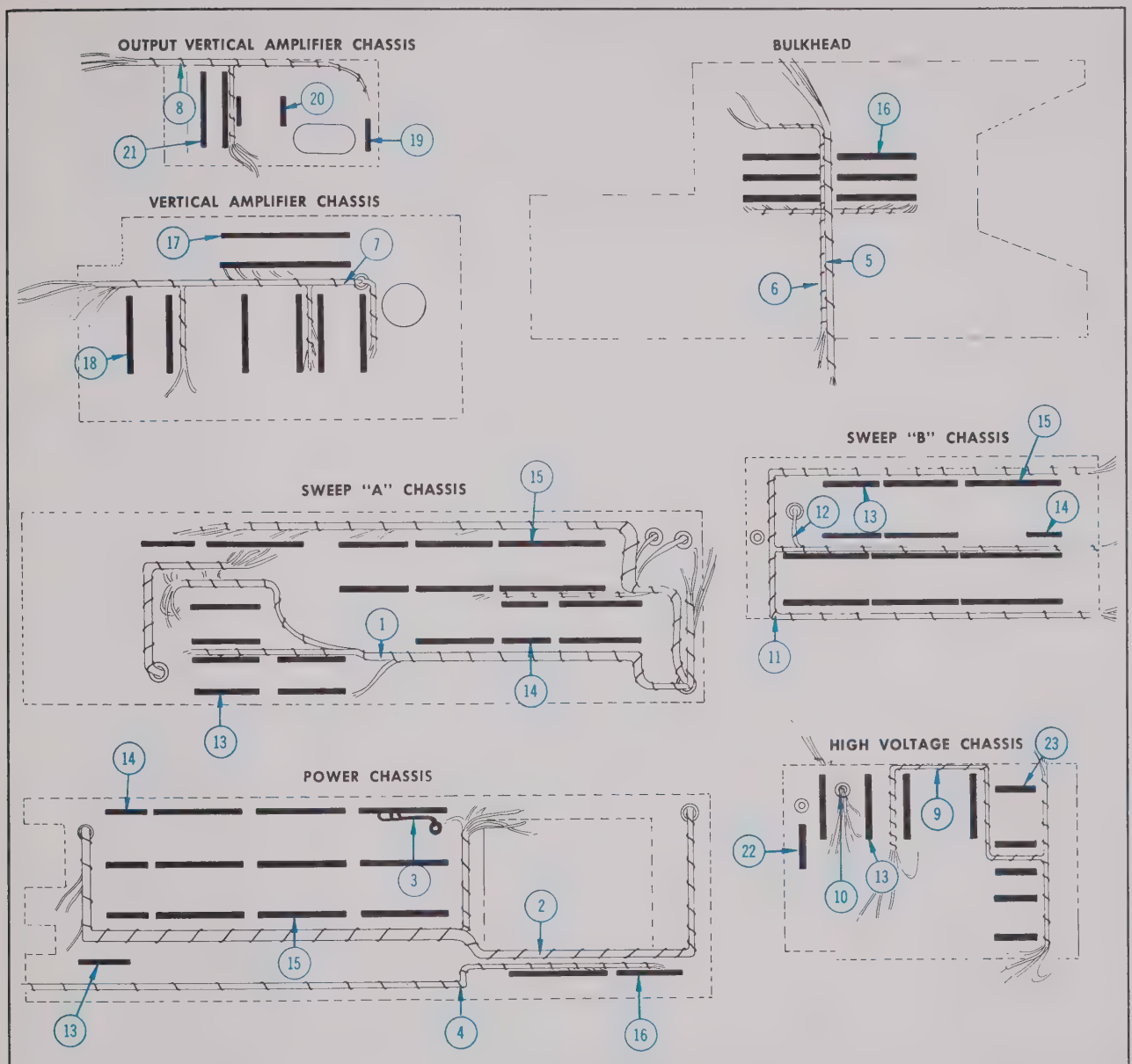
CHASSIS *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. DISC.	SERIAL/MODEL NO. EFF.	QTY.	DESCRIPTION
82	386-252			1	PLATE, fiber, small
	- - - -			-	Mounting Hardware: (not included)
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
	211-534			2	SCREW, 6-32 x 5/16 inch PHS with lockwasher
83	200-257			1	COVER, capacitor
84	214-210			1	SPOOL, solder, assembly
85	343-095			1	CLAMP, tube
	- - - -			-	Mounting Hardware: (not included)
	210-004			1	LOCKWASHER, internal, #4
	210-406			1	NUT, hex, 4-40 x 3/16 inch
	211-008			1	SCREW, 4-40 x 1/4 inch BHS
86	- - - -			-	Capacitor Mounting Hardware:
	210-006			2	LOCKWASHER, internal, #6
	210-407			2	NUT, hex, 6-32 x 1/4 inch
	211-514			2	SCREW, 6-32 x 3/4 inch BHS
87	386-253			1	PLATE, small capacitor mounting
	432-047			1	BASE, metal, small capacitor
88	441-475			1	CHASSIS, high voltage
	- - - -			-	Mounting Hardware: (not included)
	166-143			2	TUBE, spacer, 3/8 OD x 13/16 inch
	212-020			2	SCREW, 8-32 x 1 inch BHS
	212-039			2	SCREW, 8-32 x 3/8 inch THS
89	136-181			13	SOCKET, 3 pin transistor
	- - - -			-	Mounting Hardware For Each: (not included)
	354-234			1	RING, mounting
90	380-048			1	HOUSING, high voltage
	- - - -			-	Mounting Hardware: (not included)
	211-507			3	SCREW, 6-32 x 5/16 inch BHS
91	392-147			1	BOARD, high voltage assembly
	- - - -			-	Includes:
92	124-162			1	STRIP, ceramic, 7/16 x 4 notches
	- - - -			-	Includes:
	355-046			1	STUD, nylon
	- - - -			-	Mounting Hardware: (not included)
	361-007			1	SPACER, nylon
	124-164			2	STRIP, ceramic, 4 notches
	124-163			4	STRIP, ceramic, 2 notches
	- - - -			-	Mounting Hardware For Board: (not included)
	211-507			1	SCREW, 6-32 x 5/16 inch BHS
93	166-357			1	SLEEVE, high voltage anode lead
94	210-966			2	WASHER, insulating, rubber, 7/16 ID x 7/8 inch OD
95	166-319			2	SLEEVE, high voltage
96	210-261			2	LUG, solder, high voltage
	- - - -			-	Mounting Hardware For Each: (not included)
	211-587			1	SCREW, 6-32 x 7/32 inch HHS
97	200-475			1	COVER, high voltage
	- - - -			-	Mounting Hardware: (not included)
	210-801			2	WASHER, 5S x 9/32 inch

CHASSIS *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
98	211-0521-00			2	SCREW, 6-32 x 1½ inches RHS
99	- - - - - -			-	High Voltage Transformer Mounting Hardware:
	210-0801-00			2	WASHER, 5S x 9/32 inch
	211-0553-00			2	SCREW, 6-32 x 1½ inches THS
	358-0228-00			2	BUSHING, insulator
100	337-0566-00			1	SHIELD, high voltage
	- - - - - -			-	Mounting Hardware: (not included)
	211-0504-00			4	SCREW, 6-32 x ¼ inch BHS
	211-0541-00			1	SCREW, 6-32 x ¼ inch FHS
101	441-0563-00	100	6849	1	CHASSIS, upper vertical amplifier
	441-0563-01	6850		1	CHASSIS, upper vertical amplifier
	- - - - - -			-	Mounting Hardware: (not included)
	210-0458-00			2	NUT, keps, 8-32 x 11/32 inch
	212-0023-00			2	SCREW, 8-32 x 3/8 inch BHS
102	136-0072-00			2	SOCKET, 9 pin, UHF
	- - - - - -			-	Mounting Hardware For Each: (not included)
	213-0044-00			2	SCREW, thread forming, 5-32 x 3/16 inch PHS
103	426-0121-00			1	HOLDER, toroid
104	406-0635-00	100	6839	1	BRACKET, pot, delrin
	- - - - - -			-	Mounting Hardware: (not included)
	213-0035-00	100	6839	2	SCREW, thread forming, 4-40 x ¼ inch PHS
	407-0347-00	6840		1	BRACKET
	- - - - - -			-	Mounting Hardware: (not included)
	211-0097-00	6840		2	SCREW, 4-40 x 5/16 inch, PHS
	210-0586-00	6840		2	NUT, keps, 4-40 x ¼ inch
105	- - - - - -			-	Resistor Mounting Hardware:
	210-0478-00			1	NUT, hex, 5/16 x 21/32 inch
	210-0601-00			1	EYELET, brass, tapered barrel
	211-0507-00			1	SCREW, 6-32 x 5/16 inch BHS
	211-0553-00			1	SCREW, 6-32 x 1½ inches THS
106	343-0004-00			4	CLAMP, cable, 5/16 inch, plastic
	- - - - - -			-	Mounting Hardware For Each: (not included)
	210-0457-00			1	NUT, keps, 6-32 x 5/16 inch
	210-0803-00			1	WASHER, 6L x 3/8 inch, flat
	211-0507-00			1	SCREW, 6-32 x 5/16 inch BHS
107	343-0089-00			3	CLAMP, cable, snap-in
108	385-0137-00			1	ROD, delrin, 2¼ inches
	- - - - - -			-	Mounting Hardware: (not included)
	213-0041-00			1	SCREW, thread forming, 6-32 x 3/8 inch
109	343-0004-00			1	CLAMP, cable, 5/16 inch plastic
	- - - - - -			-	Mounting Hardware: (not included)
	212-0004-00			1	SCREW, 8-32 x 5/16 inch BHS
	210-0804-00			1	WASHER, 8S x 3/8 inch
110	343-0006-00	100	218X	1	CLAMP, cable, ½ inch
	- - - - - -			-	Mounting Hardware: (not included w/clamp)
	212-0008-00	100	218	1	SCREW, 8-32 x ½ inch BHS
	212-0023-00	219		1	SCREW, 8-32 x 3/8 inch BHS
	210-0863-00			1	WASHER, "D" type
111	210-0204-00	100	449	1	LUG, solder, DE #6
	210-0201-00	450		1	LUG, solder, SE #4
	- - - - - -			-	Mounting Hardware: (not included w/lug)
	213-0044-00			1	SCREW, thread cutting, 5-32 x 3/16 inch PHS
112	136-0011-00			1	SOCKET, STM8G
	- - - - - -			-	mounting hardware: (not included w/socket)
	211-0538-00	X490		2	SCREW, 6-32 x 5/16 inch, FHS
	210-0006-00			2	LOCKWASHER, internal, #6
	210-0407-00			2	NUT, hex., 6-32 x ¼ inch

CABLE HARNESS & CERAMIC STRIP DETAIL

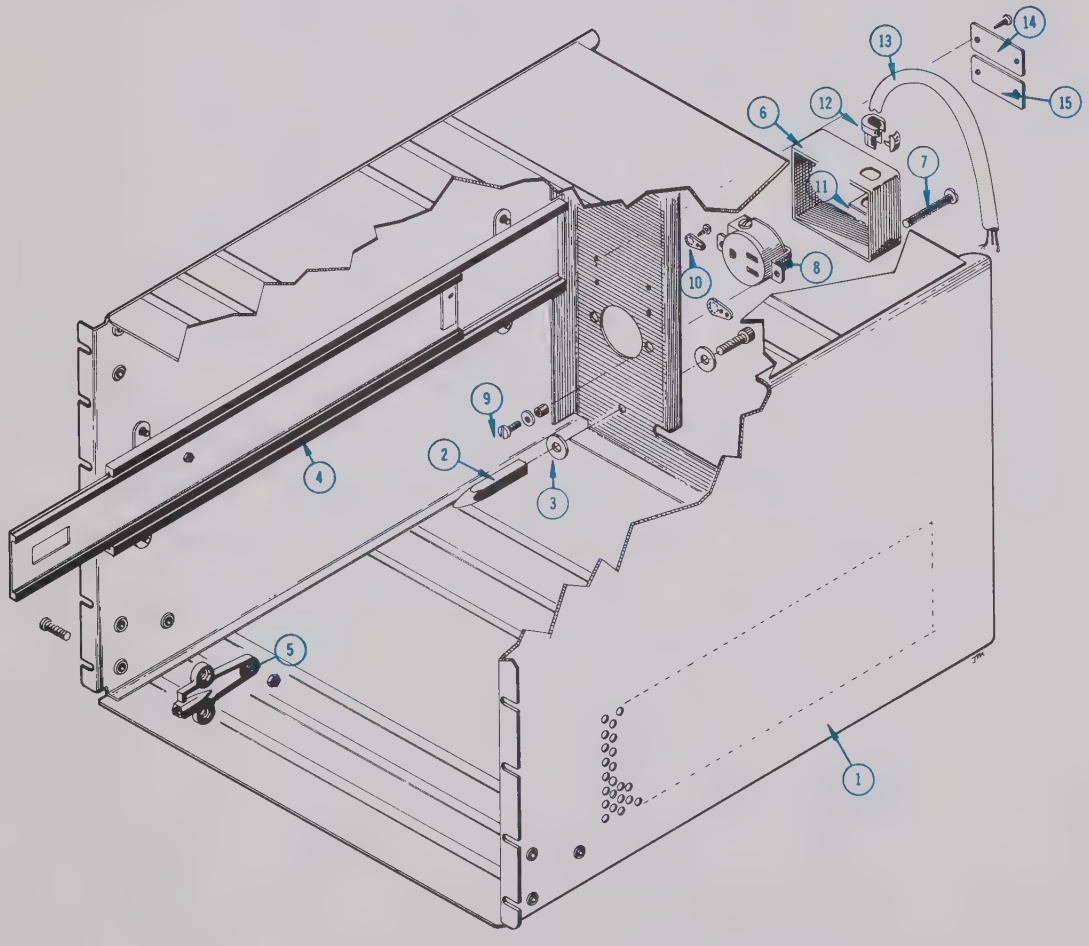


REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	179-0925-00	100	8589	1	CABLE HARNESS, sweep
	179-0925-01	8590		1	CABLE HARNESS, sweep
2	179-0893-00	100	8869	1	CABLE HARNESS, power #1
	179-0893-01	8870		1	CABLE HARNESS, power #1
3	179-0324-00			1	CABLE HARNESS, #2
4	179-0306-00	100	8869	1	CABLE HARNESS, power 110 Volt
	179-0306-01	8870		1	CABLE HARNESS, power 110 Volt
5	179-0894-00	100	8869	1	CABLE HARNESS, rectifier
	179-0894-01	8870		1	CABLE HARNESS, rectifier
6	179-0895-00	100	8869X	1	CABLE HARNESS, rectifier 110 Volt
7	179-0901-00			1	CABLE HARNESS, vertical amplifier
8	179-0900-00			1	CABLE HARNESS, output vertical amplifier
9	179-0899-00			1	CABLE HARNESS, focus and intensity
10	179-0904-00	100	389	1	CABLE HARNESS, high voltage
	179-0767-00	390		1	CABLE HARNESS, high voltage

CABLE HARNESS & CERAMIC STRIP DETAIL *(Cont'd)*

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
11	179-0897-00	100	6189	1	CABLE HARNESS, delay sweep #1
	179-0897-01	6190		1	CABLE HARNESS, delay sweep #1
12	179-0898-00			1	CABLE HARNESS, delay sweep #2
13	124-0089-00			17	STRIP, ceramic, 3/4 inch x 7 notches
	- - - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon
14	124-0088-00			7	STRIP, ceramic, 3/4 inch x 4 notches
	- - - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon
15	124-0091-00			25	STRIP, ceramic, 3/4 inch x 11 notches
	- - - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon
16	124-0090-00			7	STRIP, ceramic, 3/4 inch x 9 notches
	- - - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon
17	124-0145-00			2	STRIP, ceramic, 7/16 inch x 20 notches:
	- - - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon
18	124-0147-00			6	STRIP, ceramic, 7/16 inch x 13 notches
	- - - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon
19	124-0087-00			1	STRIP, ceramic, 3/4 inch x 3 notches
	- - - - - -			-	Each Includes:
	355-0046-00			1	STUD, nylon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			1	SPACER, nylon
20	124-0149-00			2	STRIP, ceramic, 7/16 inch x 7 notches
	- - - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon
21	124-0146-00			2	STRIP, ceramic, 7/16 inch x 16 notches
	- - - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon
22	124-0120-00			1	STRIP, ceramic, 4 notches
	- - - - - -			-	Includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon
23	124-0093-00			5	STRIP, ceramic, 7/16 inch x 5 notches
	- - - - - -			-	Each Includes:
	355-0046-00			2	STUD, nylon
	- - - - - -			-	Mounting Hardware For Each: (not included)
	361-0009-00			2	SPACER, nylon

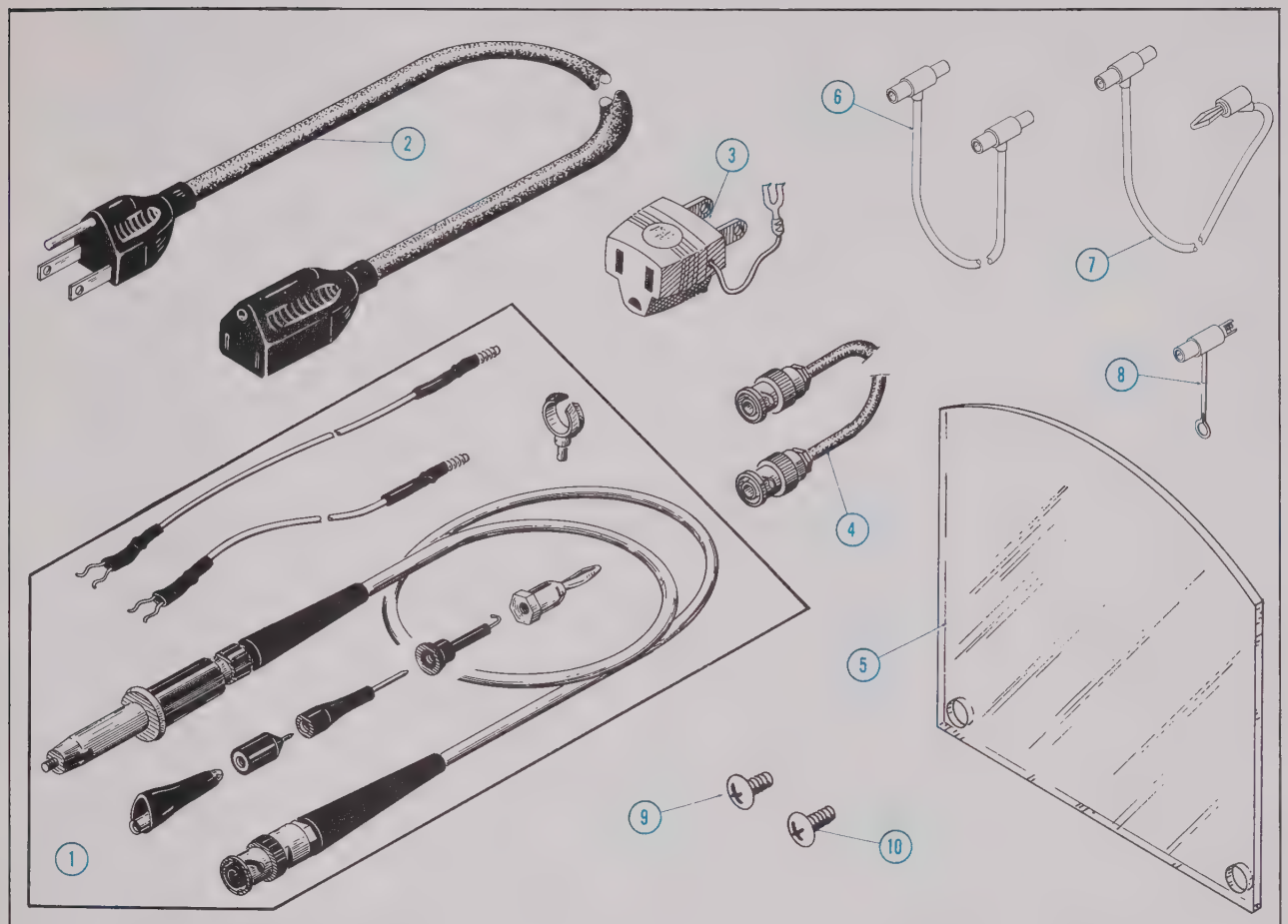
CABINET



CABINET

REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	437-0073-00	100	8869	1	CABINET, rackmount
	437-0073-01	8870		1	CABINET, rackmount
	- - - - - -			-	Includes:
2	214-0426-00			2	PIN, guide
3	- - - - - -			-	Mounting Hardware For Each: (not included)
	210-0866-00			2	WASHER, 0.264 ID x 1 1/8 inches OD
	213-0129-00			1	SCREW, socket, set, 1/4-20 x 3/4 inch
4	351-0078-00			1	GUIDE, cabinet chassis track (1 pair)
	- - - - - -			-	Mounting Hardware: (not included)
	210-0458-00			8	NUT, keps, 8-32 x 11/32 inch
5	351-0074-00			4	GUIDE, instrument position and lock
	- - - - - -			-	Mounting Hardware For Each: (not included)
	212-0023-00			3	SCREW, 8-32 x 3/8 inch BHS
	210-0409-00			3	NUT, hex, 8-32 x 5/16 inch
6	380-0066-00			1	HOUSING, AC inlet
	- - - - - -			-	Mounting Hardware: (not included)
7	211-0529-00			2	SCREW, 6-32 x 1 1/4 inches BHS
8	136-0036-00			1	SOCKET, grounding type
	- - - - - -			-	Mounting Hardware: (not included)
9	212-0023-00			2	SCREW, 8-32 x 3/8 inch BHS
	210-0804-00			2	WASHER, 8S x 3/8 inch
	166-0029-00			2	TUBE, spacer, 1/8 inch
	210-0205-00			1	LUG, solder, SE #8
10	210-0201-00			1	LUG, solder, SE #4
	- - - - - -			-	Mounting Hardware: (not included)
	213-0044-00			1	SCREW, thread cutting, 5-32 x 3/16 inch inch PHS
11	361-0011-00			1	SPACER, socket shield
12	358-0025-00			1	BUSHING, strain relief
13	161-0017-00			1	CORD, power, 8 feet, with male connector one end
14	334-0904-00	100	8869X	1	TAG, voltage rating
	- - - - - -			-	Mounting Hardware: (not included)
	213-0088-00	100	8869X	2	SCREW, thread forming, 4-40 x 1/4 inch PHS
15	334-0927-00			1	TAG, fuse data
	- - - - - -			-	Mounting Hardware: (not included)
	213-0088-00			2	SCREW, thread forming, 4-40 x 1/4 inch PHS

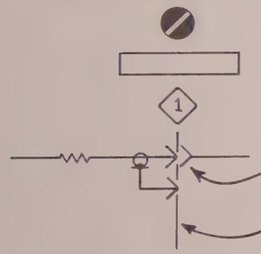
STANDARD ACCESSORIES



REF. NO.	PART NO.	SERIAL/MODEL NO. EFF.	SERIAL/MODEL NO. DISC.	QTY.	DESCRIPTION
1	010-0127-00			2	PROBE, package, P6006
2	161-0010-00	100	7289	1	CORD, power
	161-0010-03	7290		1	CORD, power
3	103-0013-00			1	ADAPTER, 3 to 2 wire
4	012-0076-00			1	CABLE, 50 Ω
5	387-0918-00			1	PLATE, protector
	378-0546-00	100	419	1	FILTER, light, smoke gray (installed)
	378-0567-00	420		1	FILTER, light, smoke gray (installed)
6	012-0031-00	100	389	1	CORD, patch
	012-0087-00	390		2	CORD, patch
7	012-0091-00	X390		1	CORD, patch
8	012-0092-00	X390		1	JACK, BNC — post
9	212-0533-00			12	SCREW, 10-24 x 5/16 inch, THS
10	212-0535-00			12	SCREW, 10-32 x 5/16 inch, THS
- -	103-0033-00	100	389X	2	ADAPTER, BNC to binding post (not shown)
	070-0438-01			2	MANUAL, instruction (not shown)

SECTION 8
DIAGRAMS

The following symbols are used on the diagrams:



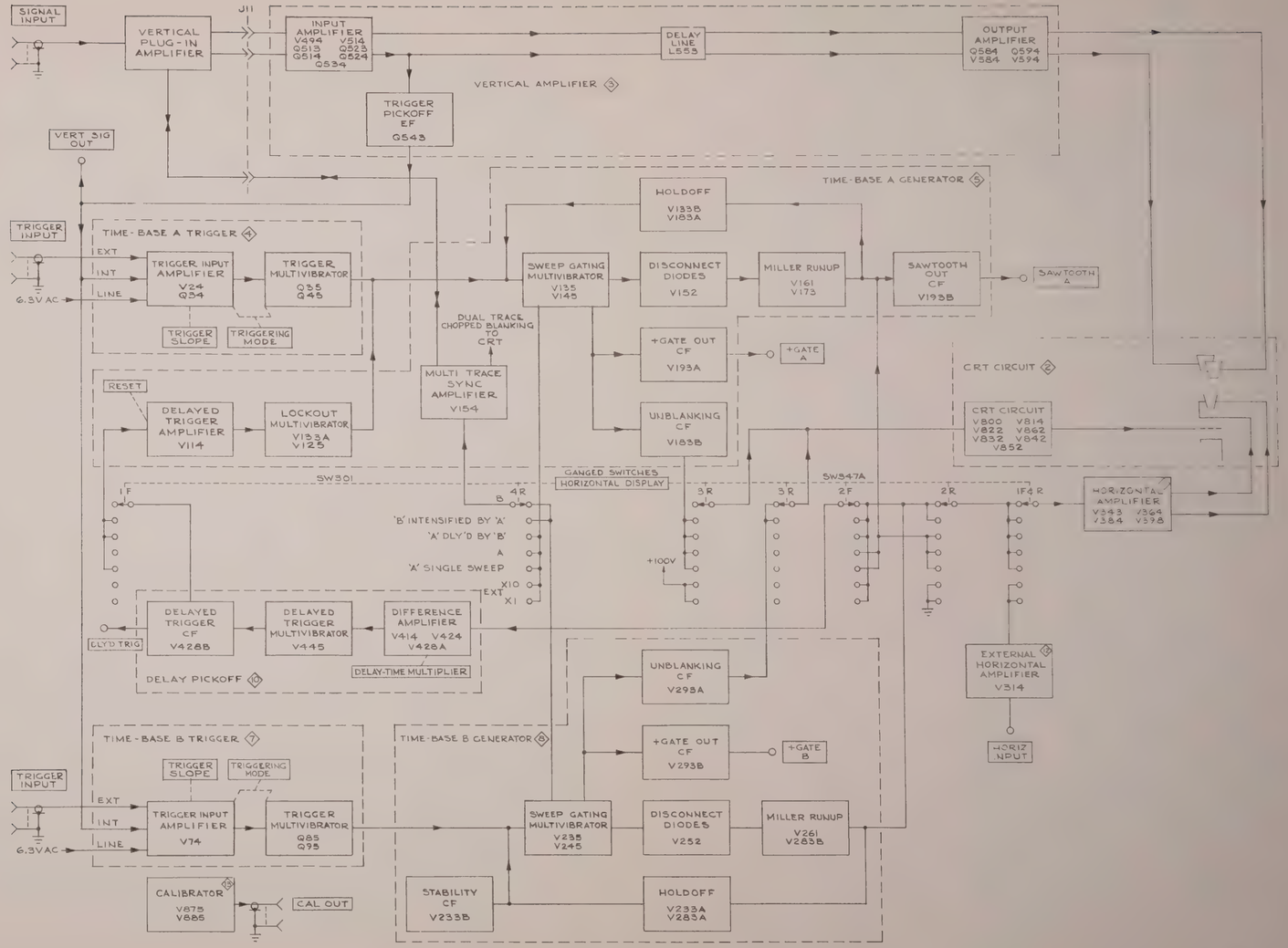
Screwdriver adjustment

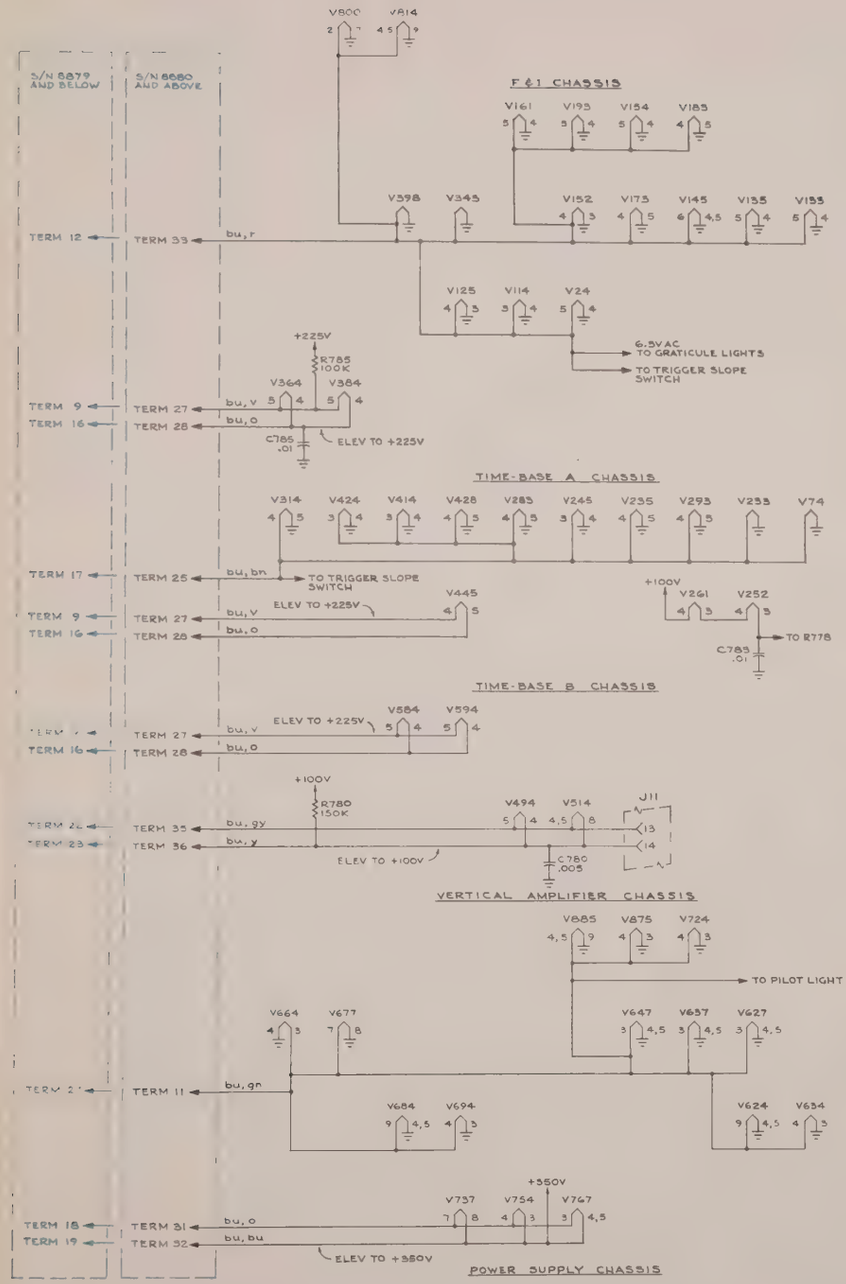
Front or rear panel control or connector

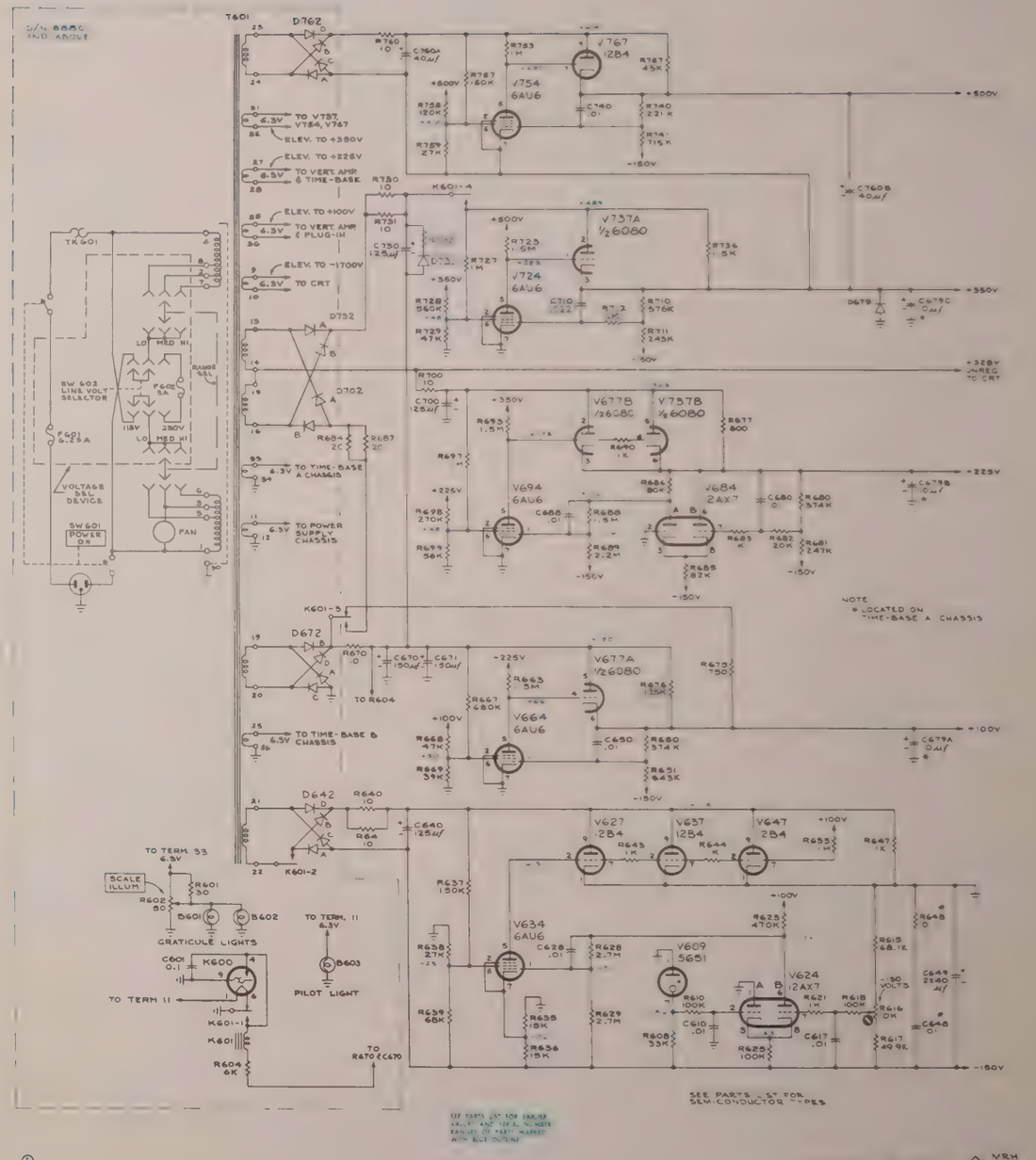
Refer to indicated diagram

Connection to circuit board made with pin connector at indicated pin

Blue line encloses components located on circuit board







TYPE RM545B OSCILLOSCOPE

HEATER WIRING DIAGRAM

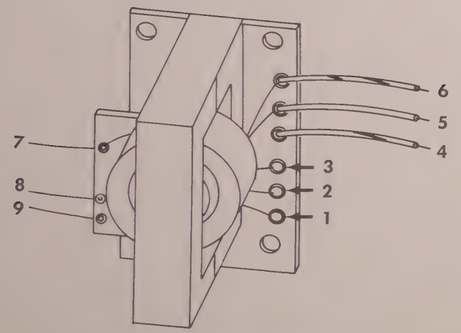
POWER SUPPLY 1 VRH 869

CRT CIRCUIT

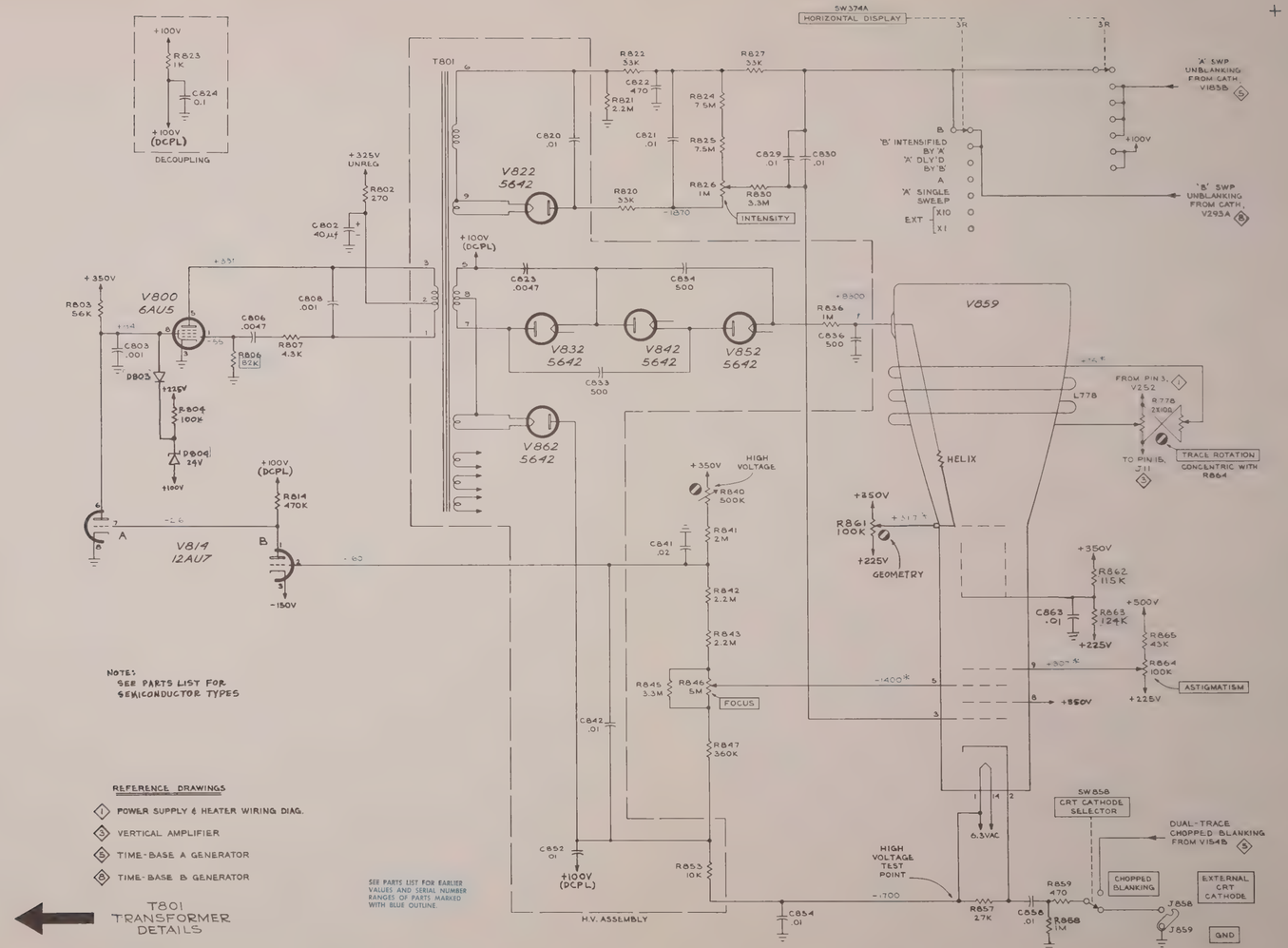
VOLTAGE READINGS were obtained under the following conditions:
INTENSITY ..... Counterclockwise

Voltage readings marked with asterisk (*) were obtained with the control set for normal operation

Also see IMPORTANT note on Time Base A Trigger Diagram.



T801 TRANSFORMER DETAILS



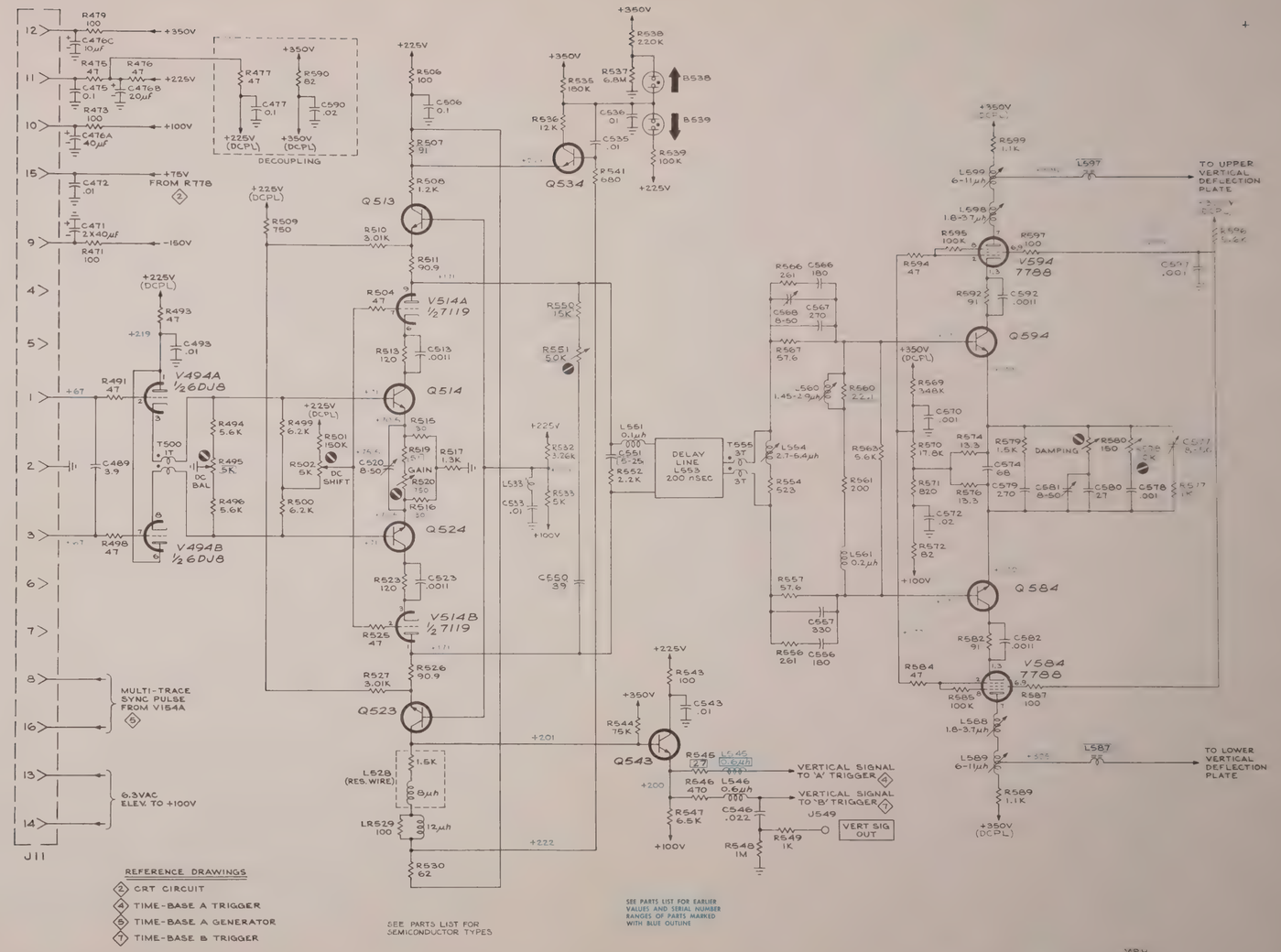
VERTICAL AMPLIFIER

VOLTAGE READINGS were obtained under the following conditions:

Input Signal	None
Test Function (Calibration Fixture)	*Common Mode

*If a letter-series or '1'-series plug-in unit is used, adjust the plug-in unit Vertical Position Control to obtain zero volts reading between pins 1 and 3 of the Interconnecting Plug.

Also see IMPORTANT note on Time Base A Trigger Diagram.



TIME BASE A TRIGGER

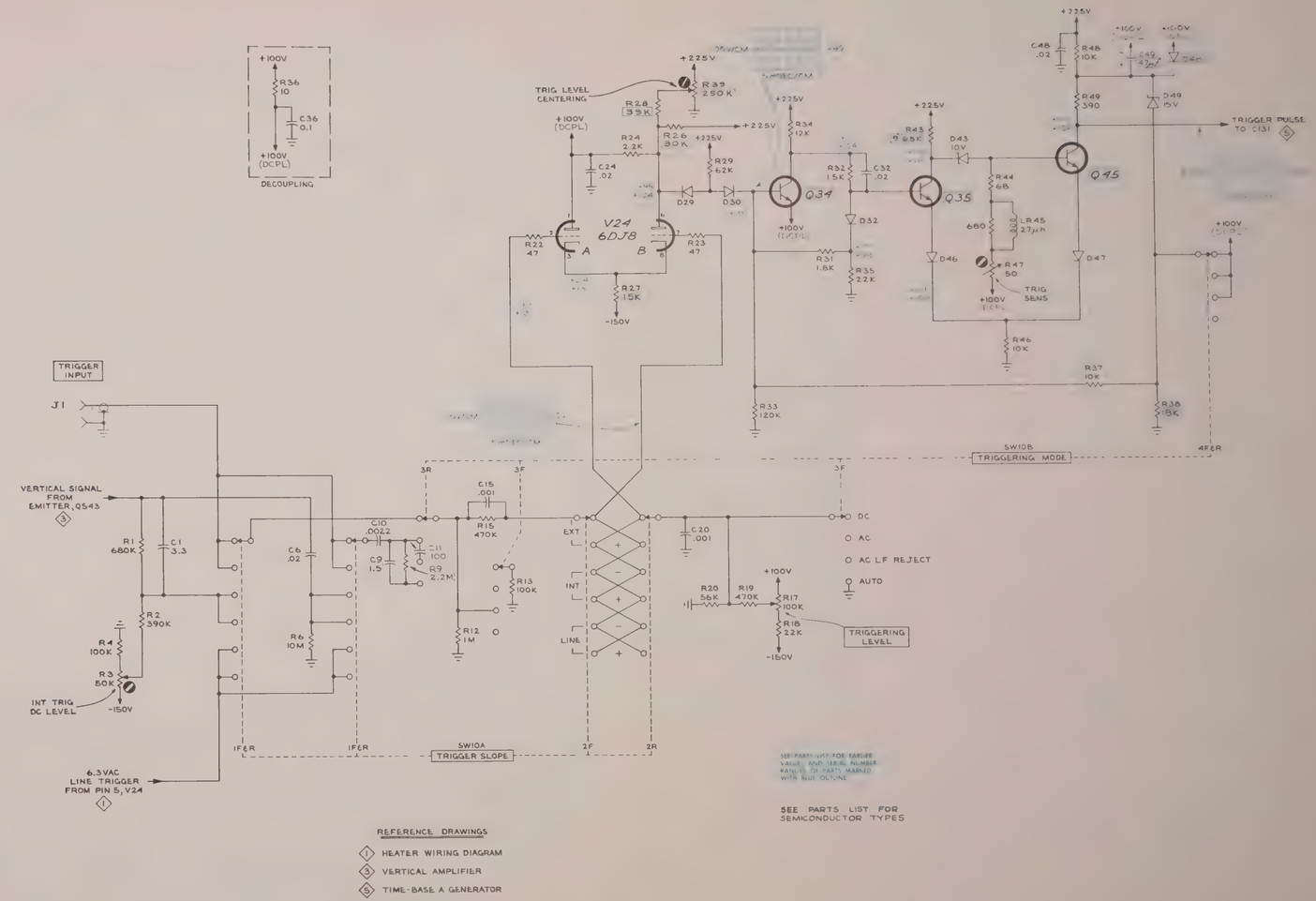
IMPORTANT

Waveforms closely approximate those found in this instrument, provided controls are set as indicated below and on each diagram.
Voltage readings were taken with a 20,000 ohms/volt voltmeter.
Before starting to check this instrument the following controls should be set, and not disturbed unless otherwise noted on the diagram being used. Return controls to the positions listed below before moving to the next diagram.

	AMPLITUDE CALIBRATOR	OFF
	HORIZONTAL DISPLAY	A
	5X MAGNIFIER	OFF
	VARIABLE (A TIME/CM)	Clockwise
	LENGTH	Clockwise
	TIME/CM	1 mSEC
Both Time Bases	TRIGGERING MODE	DC
	TRIGGER SLOPE	+EXT
	TRIGGERING LEVEL	Clockwise
	STABILITY	PRESET

WAVEFORMS AND VOLTAGE READINGS were obtained under the following conditions:

TRIGGER SLOPE	—LINE
TRIGGERING LEVEL	
For Waveforms	Centered
For Upper Voltage Reading	Counterclockwise
For Lower Voltage Reading	Clockwise



REFERENCE DRAWINGS

- (1) HEATER WIRING DIAGRAM
- (3) VERTICAL AMPLIFIER
- (5) TIME-BASE A GENERATOR

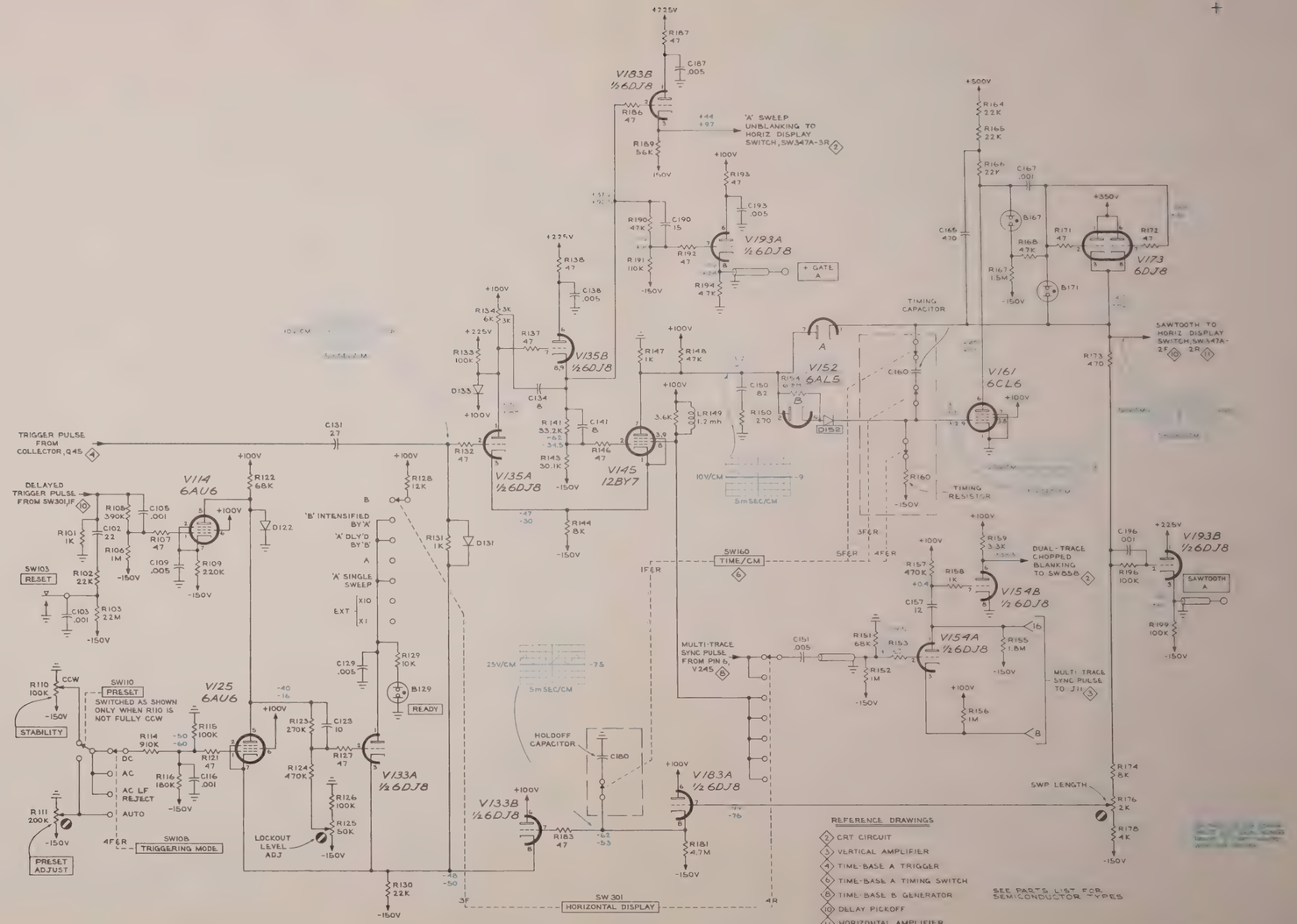
TIME BASE A GENERATOR

WAVEFORMS AND VOLTAGE READINGS were obtained under the following conditions:

STABILITY

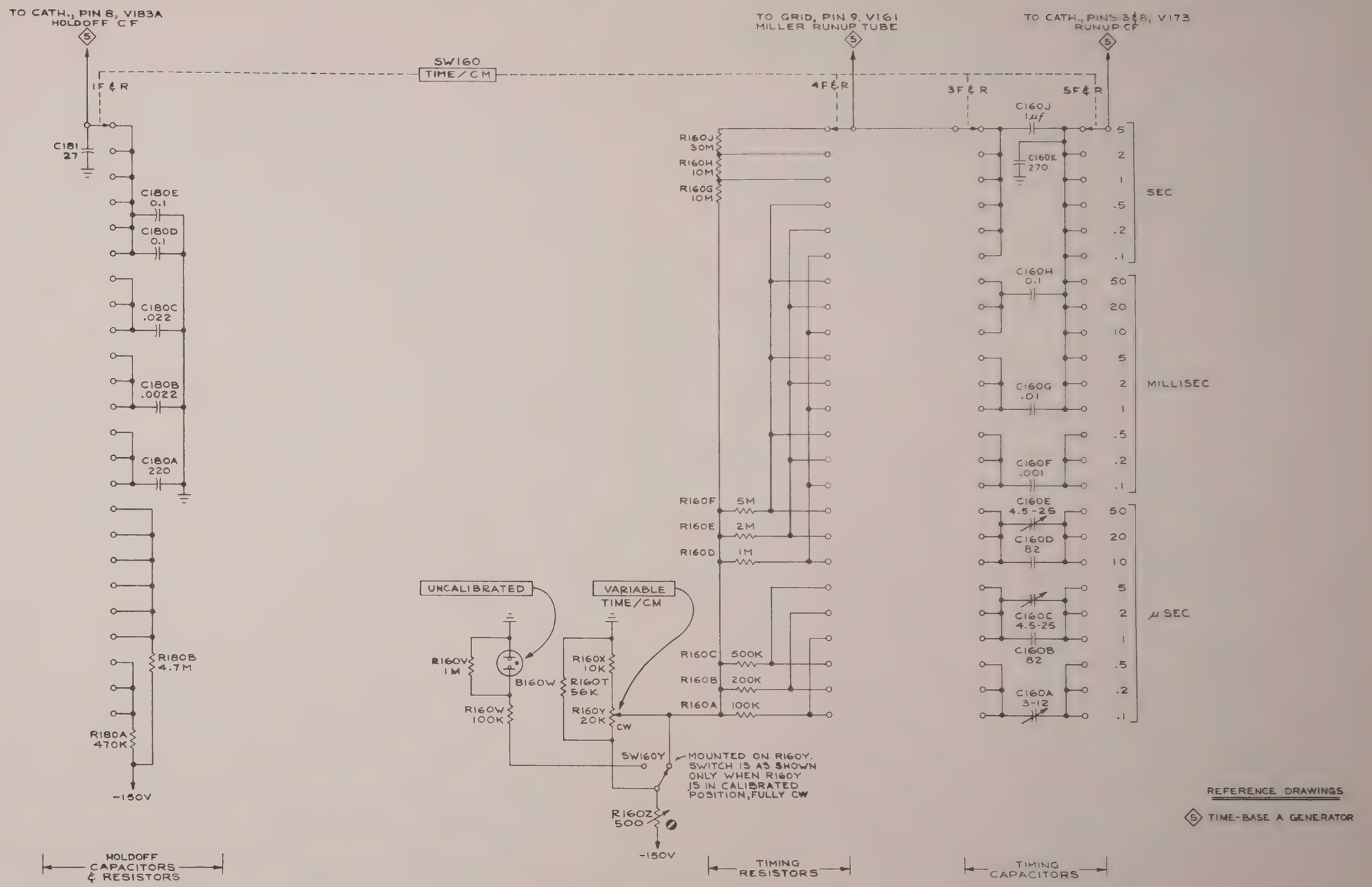
For Waveforms	Clockwise
For Upper Voltage Readings	Counterclockwise, but not switched to PRESET
For Lower Voltage Readings	Clockwise

Also see IMPORTANT note on Time Base A Trigger Diagram



TIME-BASE A GENERATOR (5)

+ TYPE RM545B OSCILLOSCOPE

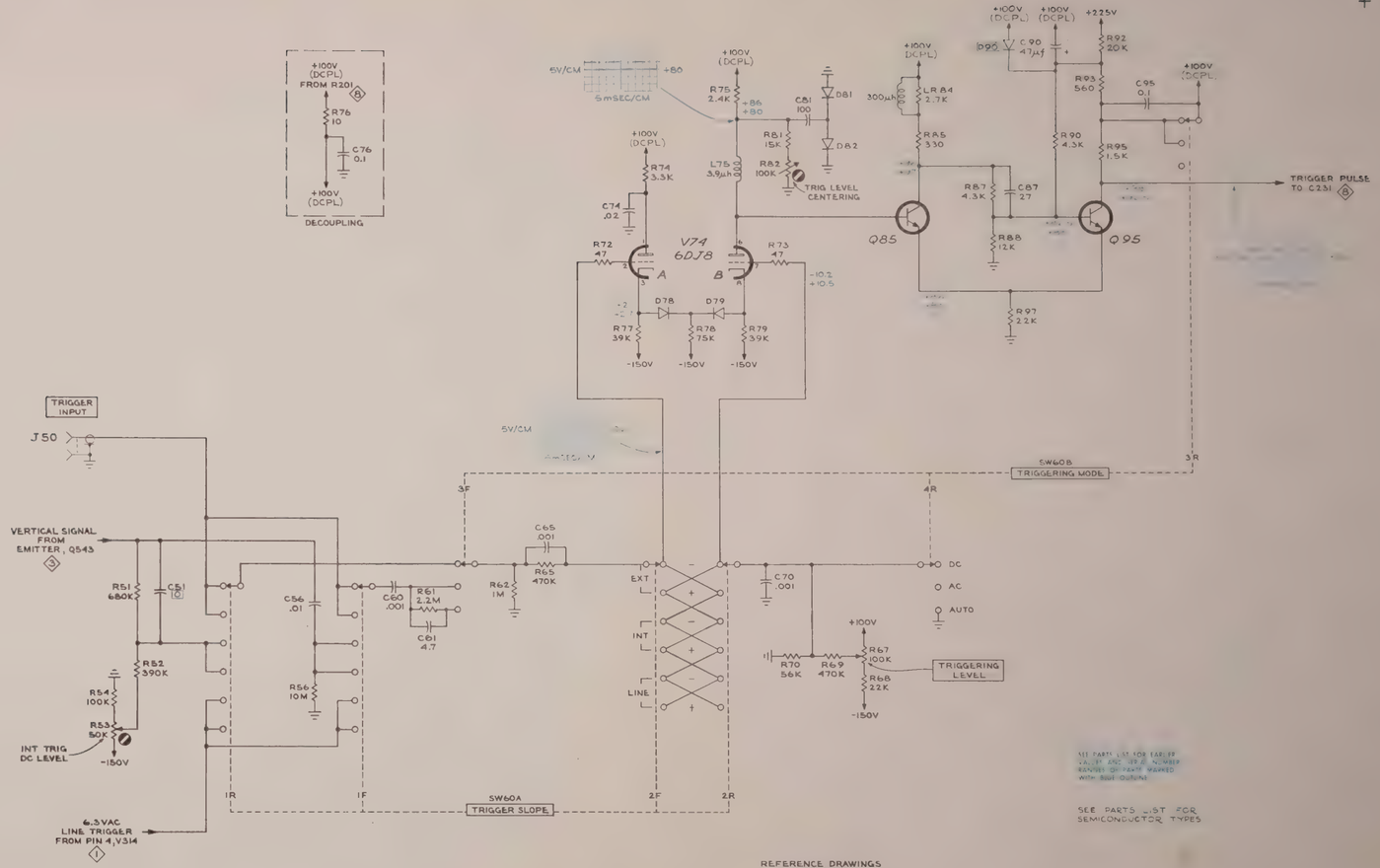

TO CATH., PIN 8, V183A
HOLDOFF CF
TO GRID, PIN 9, V161
MILLER RUNUP TUBE
TO CATH., PINS 3 & 8, V173
RUNUP CF
SW160
TIME/CM
1F & R
4F & R
3F & R
5F & R
C181
27
C180E
0.1
C180D
0.1
C180C
.022
C180B
.0022
C180A
220
R180B
4.7M
R180A
470K
-150V
R160J
30M
R160H
10M
R160G
10M
R160F
5M
R160E
2M
R160D
1M
R160C
500K
R160B
200K
R160A
100K
UNCALIBRATED
VARIABLE
TIME/CM
R160V
1M
B160W
R160W
100K
R160X
10K
R160T
56K
R160Y
20K
CW
SW160Y
MOUNTED ON R160Y. SWITCH IS AS SHOWN ONLY WHEN R160Y IS IN CALIBRATED POSITION, FULLY CW
R160Z
500
-150V
C160J
1μf
C160K
270
C160H
0.1
C160G
.01
C160F
.001
C160E
4.5-25
C160D
82
C160C
4.5-25
C160B
82
C160A
3-12
5
2
1
.5
.2
.1
SEC
50
20
10
5
2
1
.5
.2
.1
MILLISEC
50
20
10
5
2
1
.5
.2
.1
μSEC
HOLDOFF CAPACITORS & RESISTORS
TIMING RESISTORS
TIMING CAPACITORS
REFERENCE DRAWINGS
5 TIME-BASE A GENERATOR

TIME BASE B TRIGGER

WAVEFORMS AND VOLTAGE READINGS were obtained under the following conditions:

TRIGGER SLOPE ..... —LINE
TRIGGERING LEVEL
For Waveforms ..... Centered
For Upper Voltage Readings ..... Counterclockwise
For Lower Voltage Readings ..... Clockwise

Also see IMPORTANT note on Time Base A Trigger Diagram



REFERENCE DRAWINGS

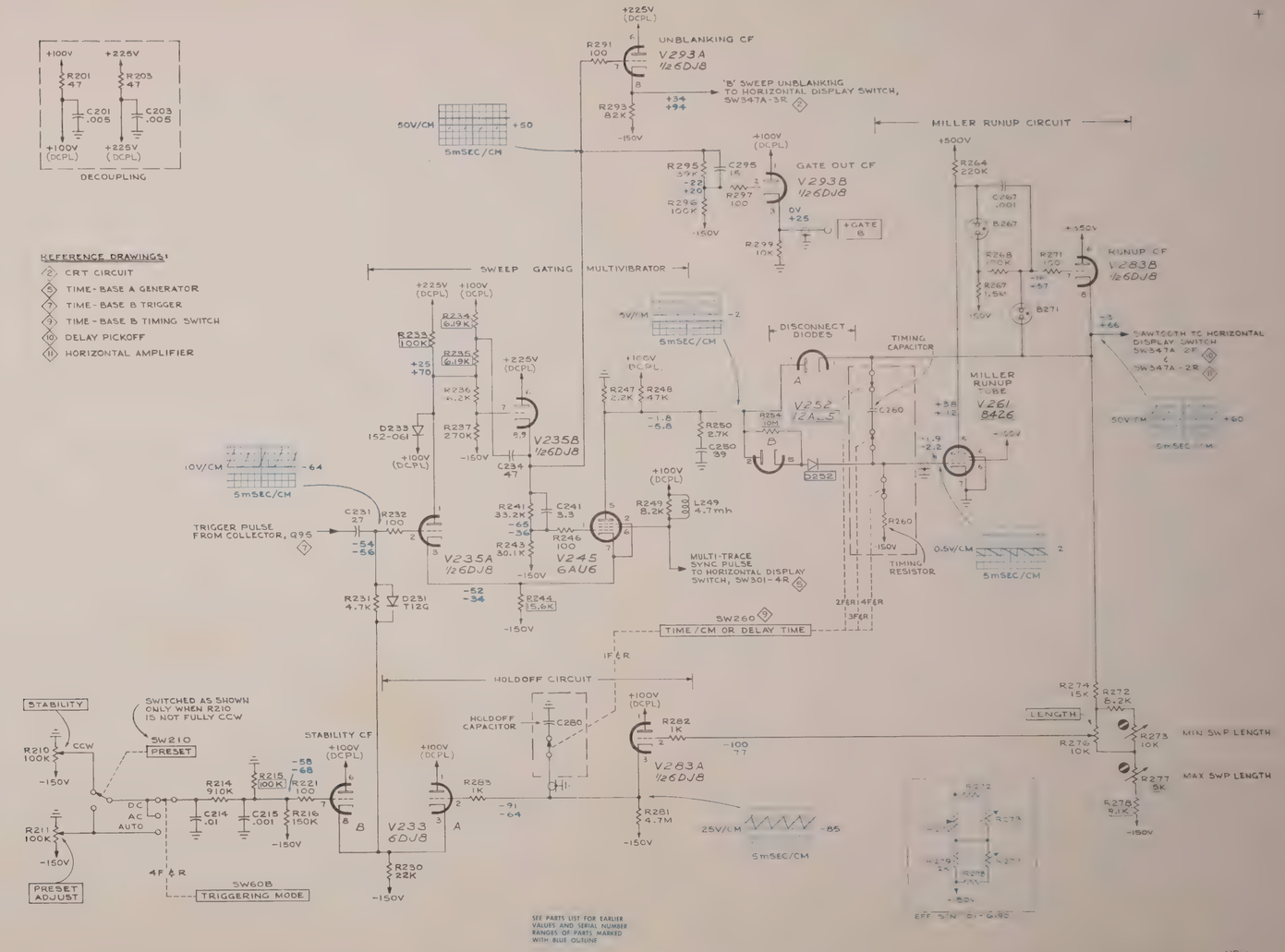
1 HEATER WIRING DIAGRAM
3 VERTICAL AMPLIFIER
6 TIME-BASE B GENERATOR

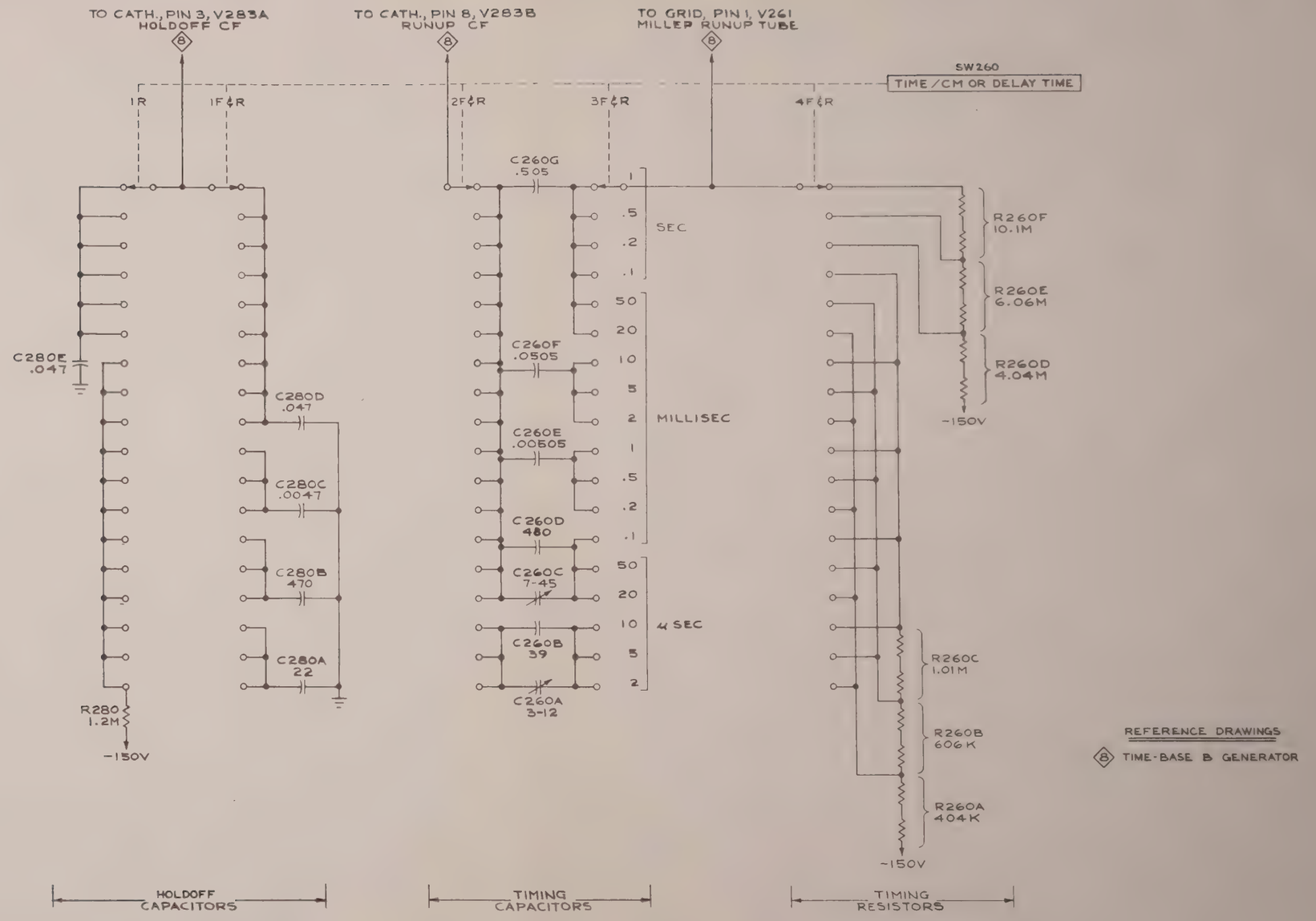
TIME BASE B GENERATOR

WAVEFORMS AND VOLTAGE READINGS were obtained under the following conditions:

LENGTH	Clockwise
STABILITY	
For Waveforms	Clockwise
For Upper Voltage Readings	Counterclockwise, but not switched to PRESET
For Lower Voltage Readings	Clockwise

Also see IMPORTANT note on Time Base A Trigger Diagram



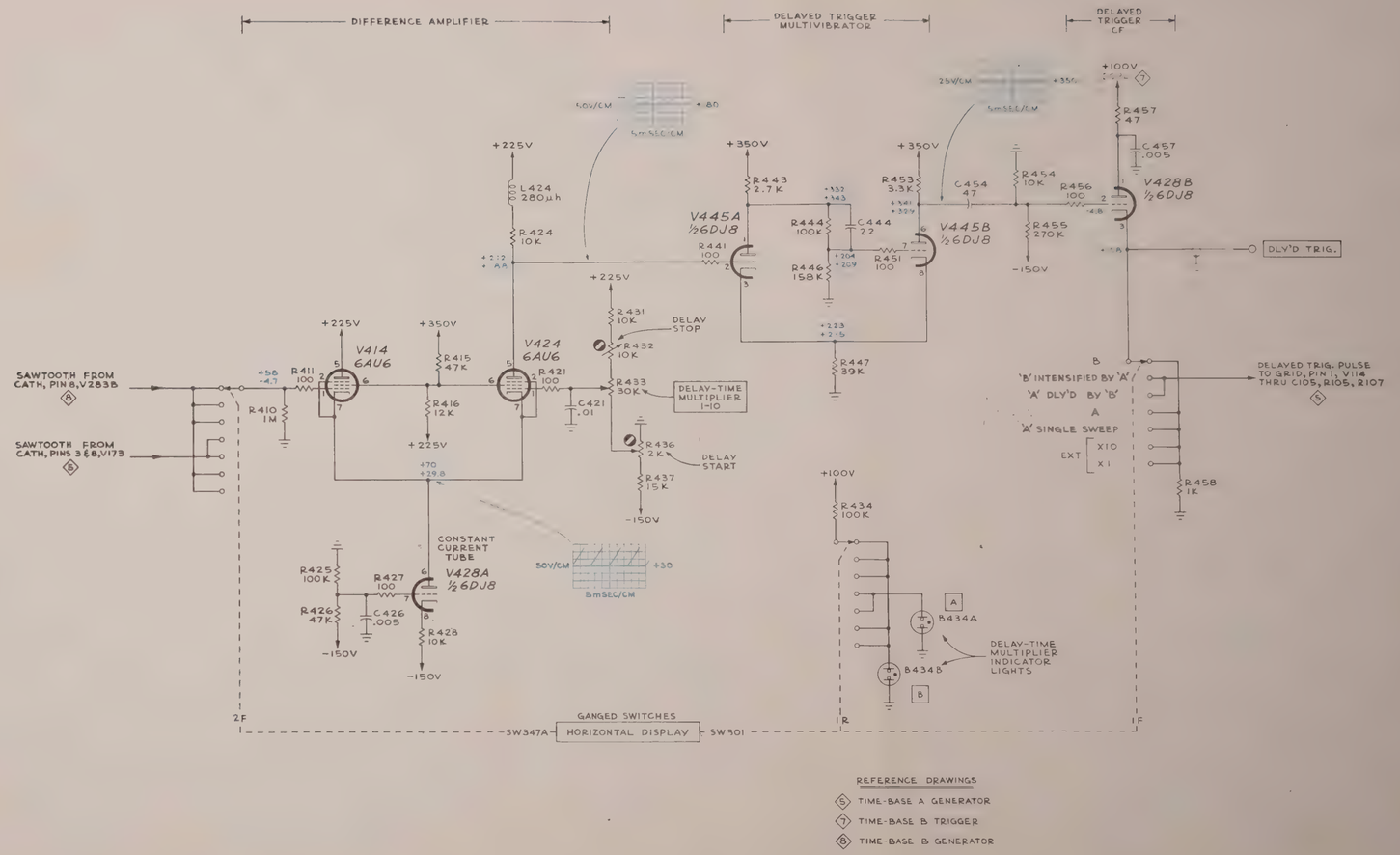

TO CATH., PIN 3, V283A
HOLDOFF CF
8
TO CATH., PIN 8, V283B
RUNUP CF
8
TO GRID, PIN 1, V261
MILLER RUNUP TUBE
8
SW260
TIME/CM OR DELAY TIME
1R
1F
2F
3F
4F
C280E
.047
C280D
.047
C280C
.0047
C280B
470
C280A
22
R280
1.2M
-150V
C260G
.505
C260F
.0505
C260E
.00505
C260D
480
C260C
7-45
C260B
39
C260A
3-12
1
.5
.2
.1
50
20
10
5
2
1
.5
.2
.1
50
20
10
5
2
SEC
MILLISEC
μSEC
R260F
10.1M
R260E
6.06M
R260D
4.04M
-150V
R260C
1.01M
R260B
606K
R260A
404K
-150V
HOLDOFF CAPACITORS
TIMING CAPACITORS
TIMING RESISTORS
REFERENCE DRAWINGS
8 TIME-BASE B GENERATOR

DELAY PICKOFF

WAVEFORMS AND VOLTAGE READINGS were obtained under the following conditions:

HORIZONTAL DISPLAY	A
DELAY-TIME MULTIPLIER 1-10	2.0
STABILITY (Time Base A)	
For Waveforms	PRESET
For Upper Voltage Readings	Clockwise
For Lower Voltage Readings	Counterclockwise, but not switched to PRESET

Also see IMPORTANT note on Time Base A Trigger Diagram

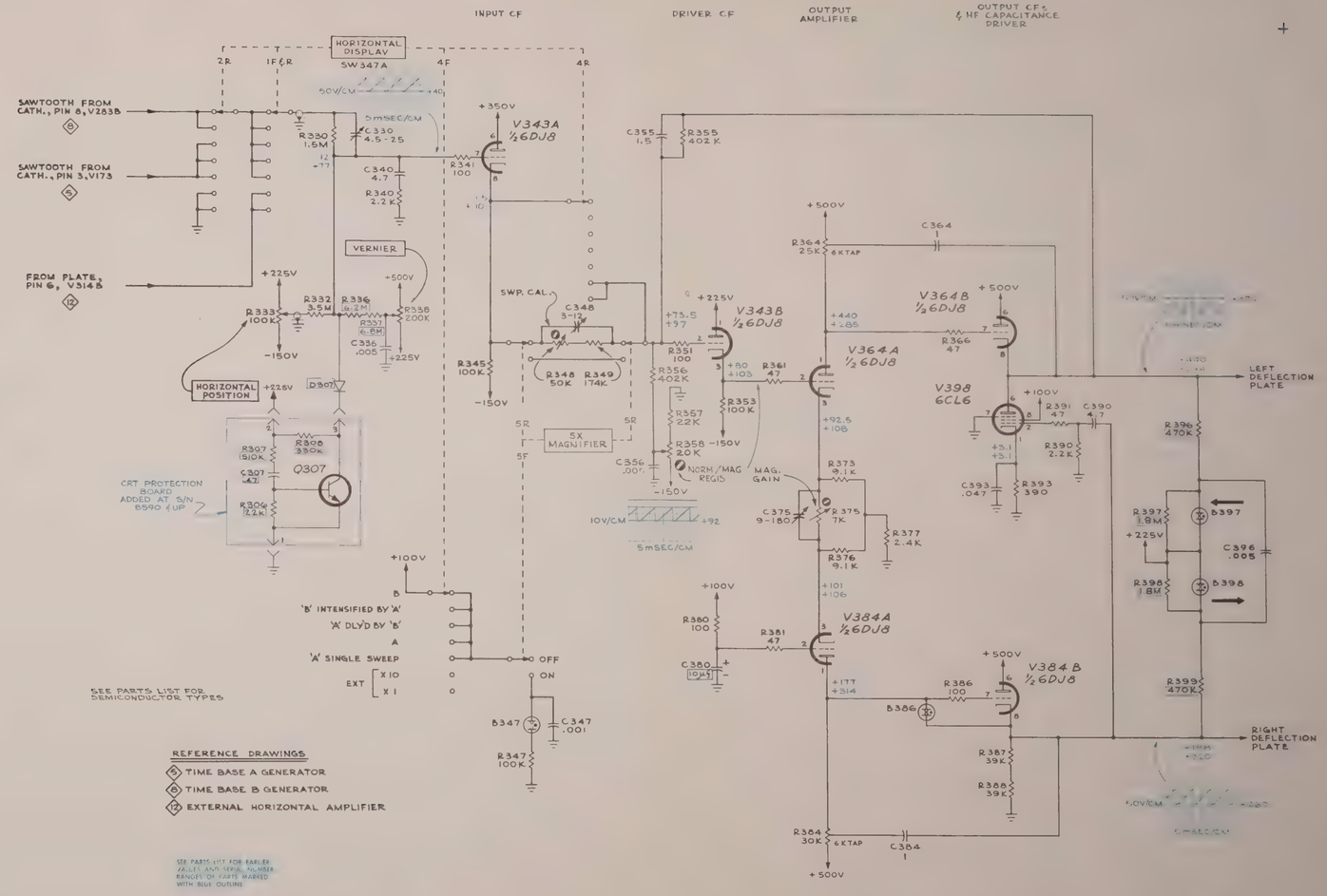


HORIZONTAL AMPLIFIER

WAVEFORMS AND VOLTAGE READINGS were obtained under the following conditions:

HORIZONTAL DISPLAY	A
STABILITY (Time Base A)	
For Waveforms	Clockwise
For Voltage Readings	PRESET
HORIZONTAL POSITION	
For Upper Voltage Readings	Counterclockwise
For Lower Voltage Readings	Clockwise

Also see IMPORTANT note on Time Base A Trigger Diagram

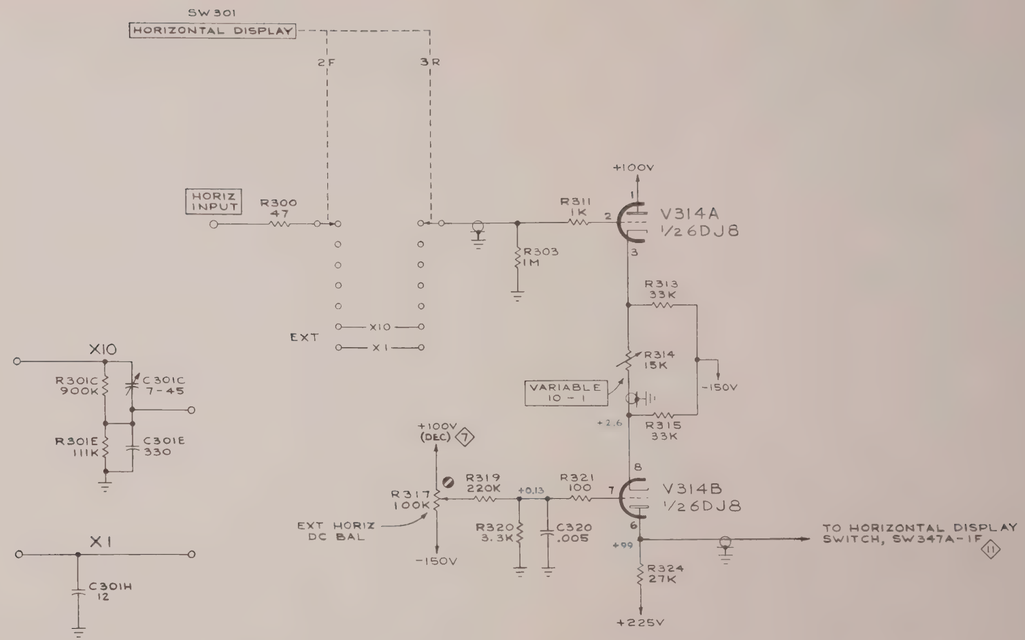


EXTERNAL HORIZONTAL AMPLIFIER

VOLTAGE READINGS were obtained under the following conditions:

External Horizontal Input Signal .... None
HORIZONTAL DISPLAY ..... EXT X10
VARIABLE 10-1 ..... Clockwise

Also see IMPORTANT note on Time Base A Trigger Diagram



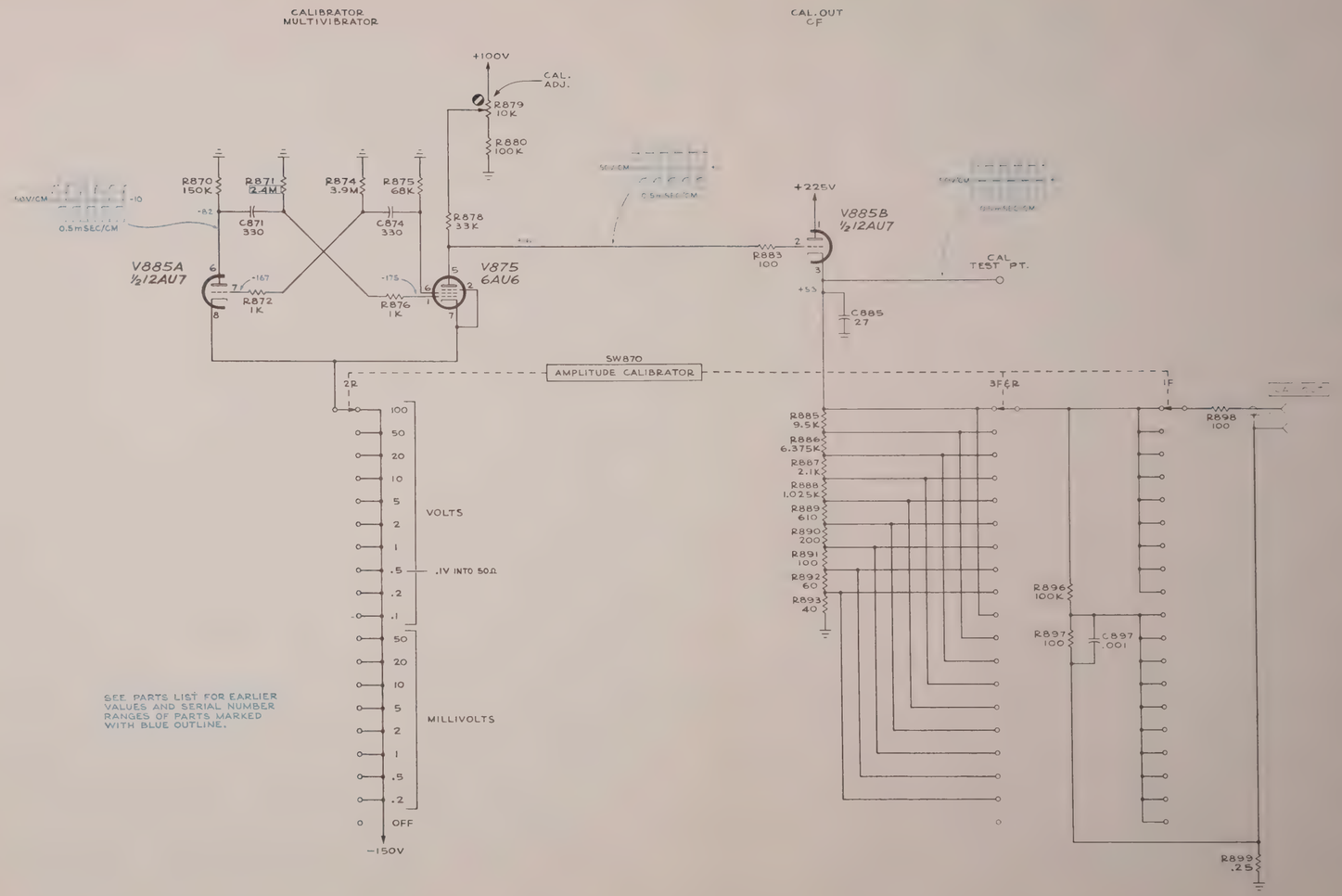
REFERENCE DRAWINGS
7 TIME-BASE B TRIGGER
11 HORIZONTAL AMPLIFIER

CALIBRATOR

WAVEFORMS AND VOLTAGE READINGS were obtained under the following conditions:

AMPLITUDE CALIBRATOR . . . . . 100 VOLTS

Also see IMPORTANT note on Time Base A Trigger Diagram



SECTION 9
RACKMOUNTING

Change information, if any, affecting this section will be found at the rear of the manual.

Mounting Methods (Figs. 9-1 and 9-2)

This instrument will fit most 19-inch wide racks whose dimensions conform to EIA specifications. The instrument cabinet is intended to be fastened directly to the front rails of a relay rack or a cabinet rack by means of the hardware supplied with the instrument. For example, Fig. 9-1 shows the instrument cabinet installed in a cabinet rack. The rear of the instrument normally needs no support, providing it is not subjected to any great amount of shock or vibration. If the instrument is to be subjected to severe shock or vibration it will be necessary to rigidly mount the rear of the cabinet to the rack. Fig. 9-1 shows the rear of the cabinet mounted to the rack with hardware provided in modification kit 016-0060-00.

The instrument is locked into its cabinet by means of four slotted LOCK knobs on the front panel. When these knobs are turned to release the instrument, it can be pulled out of the cabinet like a drawer to its fully extended position (see Fig. 9-2) and then tilted up or down and locked in one of several positions—horizontal, or 45°, 90°, and 105° from horizontal. These various positions permit many routine maintenance functions to be performed without completely removing the instrument from the rack.

Instrument Dimensions

The last pullout page in this section shows dimensional drawings of the instrument exclusive of the plug-in unit and probes.

Rack Dimensions

Width — A standard 19" rack may be used. The dimension of opening between the front rails of the rack must be at least 17 5/8".

Depth — For circulation of cooling air, allow at least 3" behind the rear and at least 2" between each side of the instrument cabinet and any enclosure on the rack. The space allowed can be reduced slightly so long as the instrument receives at least 250 cu. ft/min of air not exceeding 50°C in temperature.

In addition to the area left at the rear of the oscilloscope, about four feet should be left free in front of the instrument rack. This space will permit extending the instrument fully out of the cabinet and still have working room in front.

Rackmounting (Fig. 9-1)

To mount the instrument cabinet directly to the front and rear rails of the rack as shown in Fig. 9-1, proceed as follows:

1. Select the height on the rack where the top of the front panel is to be and mark both front rails.
2. Measure down 1 1/2 inches from the marks placed in step 1. Mark this point on both front rails. This mark is the location of the top mounting screw on each side of the cabinet.
3. Measure down 11 inches from the point found on each rail in step 2. This is the location of the bottom screws on each side of the cabinet.
4. Hold the cabinet in place and mount it with the screws provided.
5. If the instrument is to be subjected to severe shock or vibration, it will be necessary to attach the rear of the cabinet to the rack rails, using the brackets supplied in modification kit 016-0060-00. If the amount of shock or vibration is small, additional mounting screws attaching the cabinet to the rack may provide enough support.

Slideout Tracks (Fig. 9-2)

The slideout tracks for the instrument consist of two assemblies, one each for the right and left sides. Each assembly consists of three sections as illustrated in Fig. 9-3. The stationary section attaches to the cabinet front and rear, the chassis section attaches to the instrument, and the intermediate section fits between the other two sections to allow the oscilloscope to fully extend out of the rack.

The stationary and intermediate sections for both sides of the cabinet rack are a matched set and should not be separated.

Adjustments

To adjust the slideout tracks for smooth operation, proceed as follows:

1. Insert the instrument into the cabinet as shown in Fig. 9-4.

2. If the oscilloscope does not slide smoothly the detent assembly of the chassis sections may not be parallel to the bottom of the instrument and/or the eccentric pivot screws may not be set evenly so the slides are not parallel to each other. Adjust as shown in Fig. 9-5.

NOTE

If the eccentric pivot screw does not turn freely when adjusting it, the slot in the detent plate is fitting too tightly around the 1/4" diameter roll pin. This condition can be corrected as follows: Remove the nut, lockwasher and flat washer from the eccentric pivot screw. Remove the outer slide, pivot screw and dial plate. Using a round file, slightly enlarge the slot in the dial plate where the roll pin fits. Then re-mount the parts.

Front Panel Alignment and Anchor Castings (Fig. 9-1)

The four alignment and anchor castings are used to secure the instrument into the cabinet. It is possible to adjust them to position the front panel up or down, against or slightly away from the cabinet. The effect of the adjustment can only be seen when the instrument is secured in the cabinet.

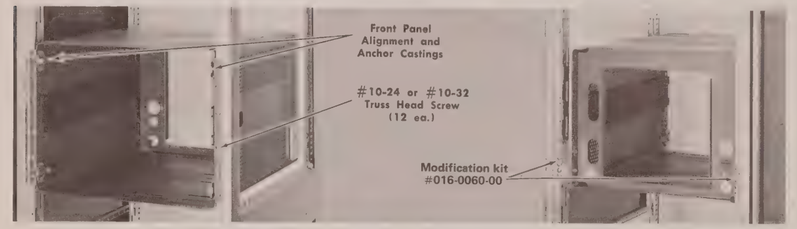


Fig. 9-1. Front and rear views of the instrument cabinet mounting.

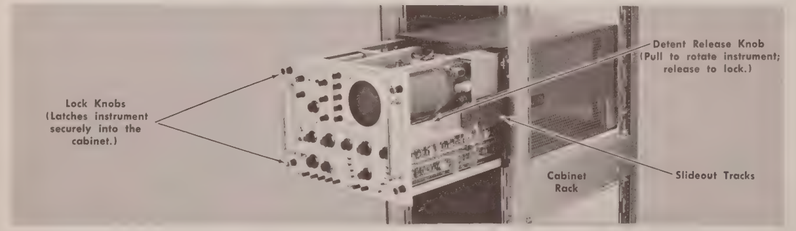

Lock Knobs (Latches instrument securely into the cabinet.)
Detent Release Knob (Pull to rotate instrument; release to lock.)
Cabinet Rack
Slideout Tracks

Fig. 9-2. Instrument extended from its cabinet.

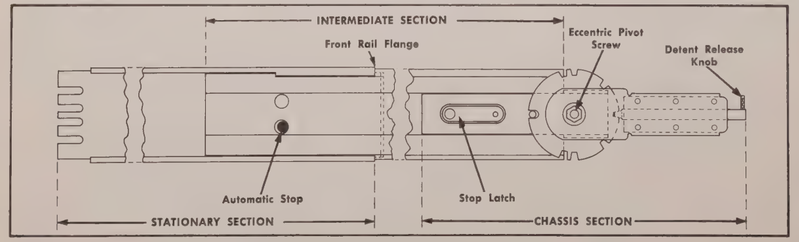


Fig. 9-3. Illustration showing the slideout track assembly for the right side.

Maintenance

The slideout tracks require no lubrication. The special gray finish on the sliding parts is a permanent lubricant.

Adjustment

This adjustment must be performed before mounting the cabinet and instrument into a rack.

1. Turn the slotted LOCK knobs to release the oscilloscope from the cabinet.
2. Pull the instrument about 2 inches out of the cabinet.
3. Loosen the three screws holding the casting to be adjusted.
4. Insert the instrument all the way into the cabinet and engage the appropriate thumb screw into the casting being adjusted. Engaging the thumb screw into the casting will position it to the proper position.
5. Tighten the three screws holding the casting.

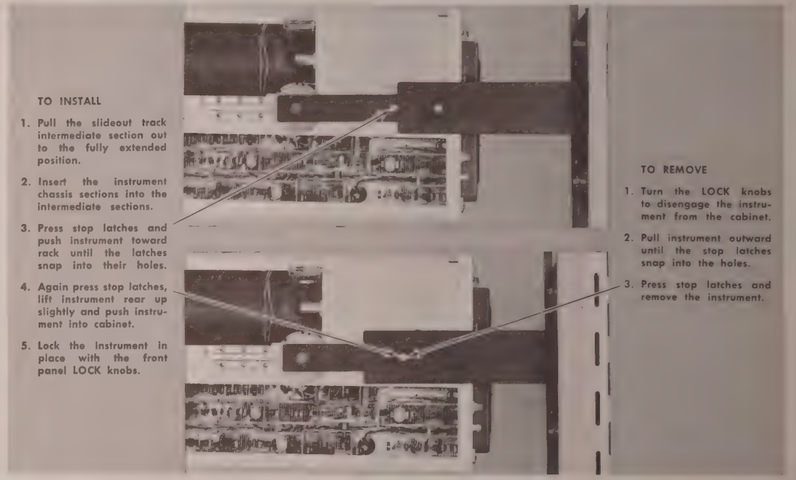

TO INSTALL
1. Pull the slideout track intermediate section out to the fully extended position.
2. Insert the instrument chassis sections into the intermediate sections.
3. Press stop latches and push instrument toward rack until the latches snap into their holes.
4. Again press stop latches, lift instrument rear up slightly and push instrument into cabinet.
5. Lock the instrument in place with the front panel LOCK knobs.
TO REMOVE
1. Turn the LOCK knobs to disengage the instrument from the cabinet.
2. Pull instrument outward until the stop latches snap into the holes.
3. Press stop latches and remove the instrument.

Fig. 9-4. Installing and removing the instrument.

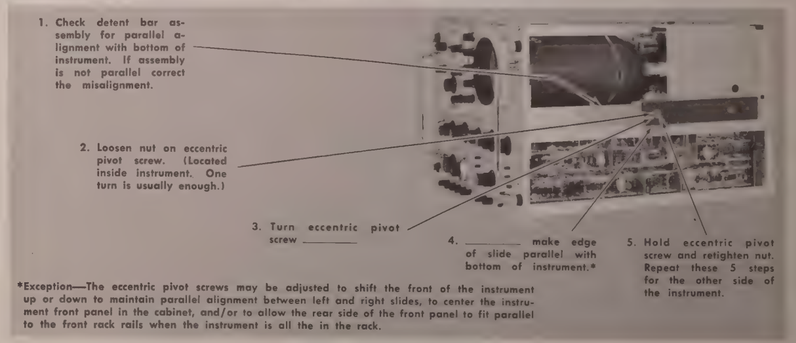
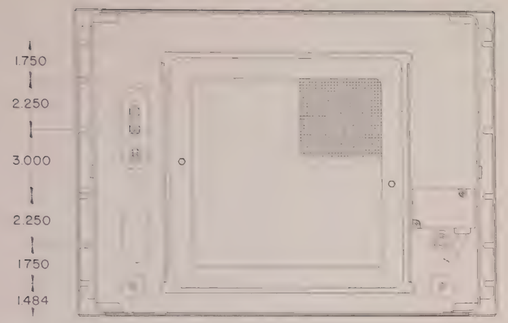
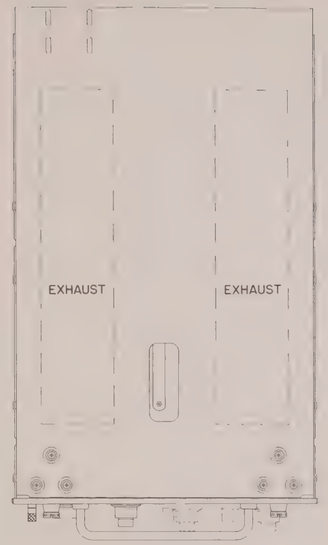
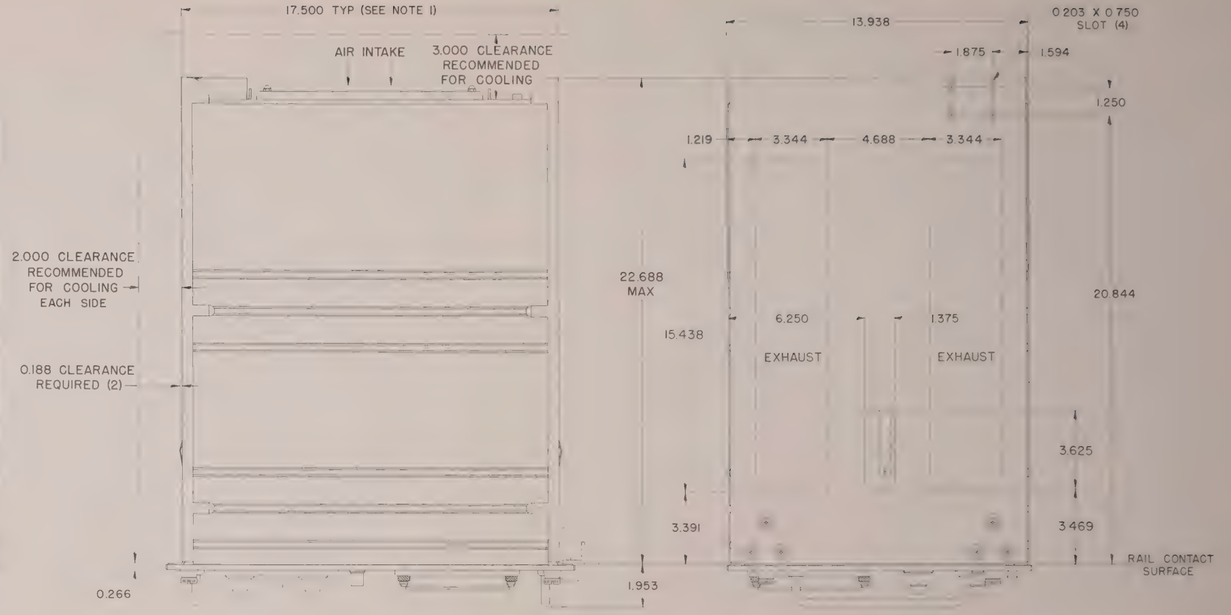

1. Check detent bar assembly for parallel alignment with bottom of instrument. If assembly is not parallel correct the misalignment.
2. Loosen nut on eccentric pivot screw. (Located inside instrument. One turn is usually enough.)
3. Turn eccentric pivot screw _____
4. _____ make edge of slide parallel with bottom of instrument.*
5. Hold eccentric pivot screw and retighten nut. Repeat these 5 steps for the other side of the instrument.
*Exception—The eccentric pivot screws may be adjusted to shift the front of the instrument up or down to maintain parallel alignment between left and right slides, to center the instrument front panel in the cabinet, and/or to allow the rear side of the front panel to fit parallel to the front rack rails when the instrument is all the in the rack.

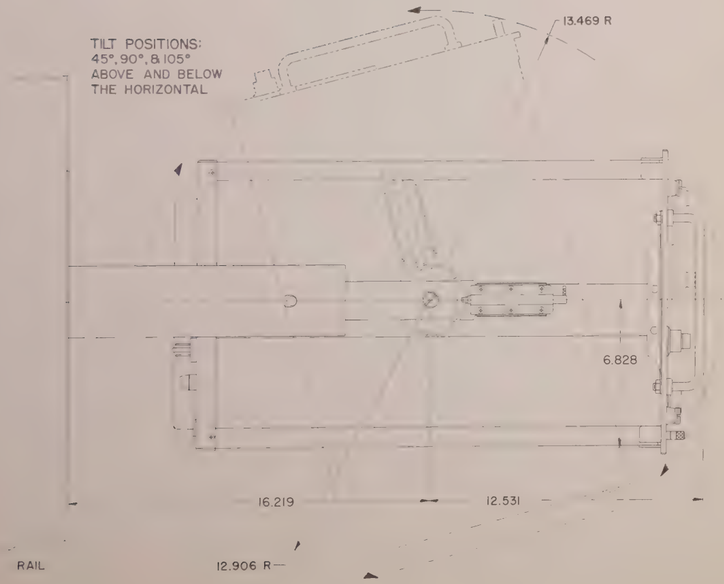
Fig. 9-5. Adjusting the chassis sections.

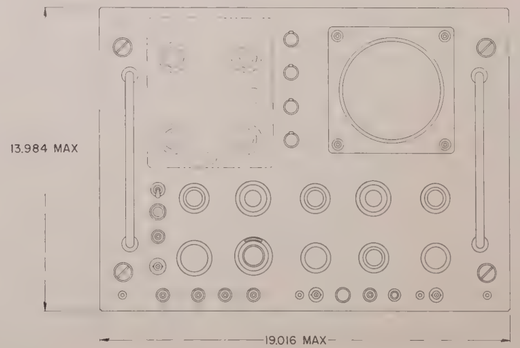


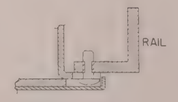
REAR VIEW











SECTION DETAIL "A"

RECOMMENDED MOUNTING

NOTES:
1. SUBJECT TO APPROXIMATELY ±0.047 DEVIATION
2. ALL DIMENSIONS ARE REFERENCE DIMENSIONS EXCEPT AS NOTED

TYPE RM545B

12 INCHES
1 INCH

A2

MANUAL CHANGE INFORMATION

At Tektronix, we continually strive to keep up with latest electronic developments by adding circuit and component improvements to our instruments as soon as they are developed and tested.

Sometimes, due to printing and shipping requirements, we can't get these changes immediately into printed manuals. Hence, your manual may contain new change information on following pages.

A single change may affect several sections. Sections of the manual are often printed at different times, so some of the information on the change pages may already be in your manual. Since the change information sheets are carried in the manual until ALL changes are permanently entered, some duplication may occur. If no such change pages appear in this section, your manual is correct as printed.